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An Examination of the Community Food Environment and the Drivers Affecting and Impacting Obesogenicity in a Deprived Urban Neighbourhood in Scotland

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Abstract

Introduction: The condition of obesity has been classified as a pandemic , given that it is negatively impacted health in almost every country in the world (1). Scotland has one of the worst obesity records in the world and one of the highest rates of all OECD countries (2). Scottish men and women in the most deprived areas had higher rates of obesity in 2016 in comparison with less deprived areas (3,4). Its alarming increasing trend year on year and the magnitude of the level of obesity over the last 30 years, coupled with the causality network which appears to be rooted in health inequities has been made obesity a titan challenge of the 21st century (1,5,6). No country in the world has reversed the challenge of obesity. The community food environment has been identified as one of the environmental causes of obesity (7–9). The high presence and accessibility of less healthy food sources appears to determine an increased availability of high-energy dense food, and the lower presence and accessibility of healthier food outlets also decreases the availability and shopping possibilities for more nutritious products (7–9). Both scenarios encourage a more frequent consumption of obesogenic food, promoting a rapid and sustained weight increase in all age groups, but especially among adults and elders (6,7,10). This thesis is the first study in Scotland that has mapped a complete foodscape or food map in a deprived neighbourhood and identify some key contributors that promote obesity.

Methodology and methods: the study was conducted in a Scottish urban neighbourhood, which is low-income with high levels of poverty and obesity and poor dietary patterns. Data collection made use of a combination of different databases and approaches, including ethnographic fieldwork and online validation. Predominance, proximity and density of all type food sources, and healthier and less healthy food sources were calculated, using the Quantum Geographic Information System (QGIS) software. Food sources were categorised using 15-point classification tool, proposed by Lake et al

(11). Accessibility to these sources was assessed separately for general stores and healthier and less healthy categories.

Results: Findings reported a wide range of outlet types and confirmed an obesogenic food environment in the neighbourhood. Food sources related to deprivation were also present, such as food banks, whereas others such as organic food outlets which are related to more affluent areas were absent. A set of ready-made food at a low price, easy to collect or delivery at home preparations was present in over 30% of the establishments and are described in the thesis. These preparations were highly popular among the residents, and almost all the menu options were served in extra-large portions. The food outlets' showcases were often in a deteriorated state with a preponderance of special cheap offers. Most of the establishments had a small sit-in area, while promotion of food delivery and takeaway was high. A higher proportion of less healthy food sources (27.7%) than healthy food sources (5.5%) were present within the neighbourhood. Less healthy food sources, such as fast-food outlets, takeaways, and convenience stores, were highly accessible and offered a wide range of high-energy dense foods. This scenario is known as food swamp. On the opposite side, the few healthier food sources, such as supermarkets, and fruit and vegetable stores, were located further away from households than the less healthy food sources. This scenario is known as a food desert, and alongside a food swamp, they confirmed that the geographical area mapped, anonymised to *Whitewood* has a highly obesogenic food environment. This environment appeared to be encouraging unhealthy eating patterns among residents and people working and studying in the area.

Conclusions: This complete food exposure mapping showed for the first time in an area of intense deprivation, the features of a low-income food environment. Regarding the obesogenic characteristics of the food environment, results resonated with previous investigations. The presence of a food swamp and a food desert and the high accessibility of less healthy food in comparison with healthier establishments, is a scenario described

previously in literature in other countries, including the US and Canada (12,13). According to Glanz et al. and Story et al. there are common drivers related to deprivation that influence a less healthy food shopping behaviour among residents, contributing to the weight gain process (7,8,14). Although the obesity causality network is hugely complex and several determinants can potentially influence eating patterns, the community food environments quality and accessibility may be part of the factors that encourage inhabitants to eat less healthy food regularly. Obesity causes are potentiated by health inequities, and there is an urgent need to tackle the obesity problem from the roots, using a multilevel approach (5,6,15). Intervening within the food environments in deprived neighbourhoods is part of the Scottish government new food policy; however, more articulated initiatives are needed to fight against obesity, starting from tackling the roots of poverty (16,17).

Lay summary

Introduction: The condition of obesity has been classified as a global problem as it is common in all countries around the world (1). Scotland has one of the highest obesity rates in the developed world, and one of the highest rates of all OECD countries (2). Scottish men and women in the poorest areas in Scotland are more likely to be obese than those in less poor areas (3,4). Obesity is a global and a national challenge. Tackling obesity is difficult as the reasons for obesity are many and often interlinked.

One reason for obesity is the community food environment , which has been identified as a major environmental cause of obesity (7–9). In areas where there are many easy to reach food sources that sell food that is not healthy, there is an increased in the amount of high-calorie food available. And alongside the many non-healthy outlets these areas often have very few healthier food outlets which decreases the availability and promote rapid and sustained weight increase in all age groups, but especially among adults and elders (6,7,10). This thesis is the first study in Scotland that has mapped a complete food map in a low-income neighbourhood and identify some key contributors that promotes obesity.

Methodology: the study was carried out in a Scottish urban neighbourhood, which I have named Whitewood. It has a low-income with high levels of poverty and obesity and poor eating patterns. Data was collected though a range of methods including ethnographic fieldwork and online validation. The study calculated the predominance, proximity and density of all type food sources to locate which were healthier and which were less healthy food sources. I used the Quantum Geographic Information System (QGIS) software. Food sources were categorised using 15-point classification tool, proposed by Lake et al. (11). I measured how far it was to walk to healthy and non healthy food outlets and how long it took from different points in the neighbourhood.

Results: The findings of the study showed that the area was an obesogenic food environment in the neighbourhood. Food sources related to deprivation were also present, such as food banks whereas others as organic food outlets which are related to wealthier areas were absent. A set of less healthy preparations ready to takeaway was present in over 30% of the establishments and described in the thesis. These preparations apparently were highly popular among the residents, and almost all the menu options were served in extra-large portions. The food outlets' showcases were often in a deteriorated state and full of special cheap offers. Most of the shops have a small area for a sit-in, while promotion of food delivery and takeaway was high. A higher proportion of less healthy food sources (27.7%) than healthy food sources (5.5%) were present within the neighbourhood. Less healthy food sources, such as fast-food outlets, takeaways and convenience stores, were highly accessible and offering a wide range of different foods. This scenario is known as food swamp. In the opposite side, the few healthier food sources, such as supermarkets, fruits and vegetable stores, were located further away from households than the less healthy food sources. This scenario is known as a food desert, and alongside a food swamp, they confirmed that Whitewood neighbourhood has a highly obesogenic food environment and presumably this environment is encouraging unhealthy eating patterns among residents and people working and studying in the area.

Conclusions: The study produced a complete food map in an area of intense poverty and showed the features of a low-income food environment. The results were similar to those from other studies with regard to the obesogenic findings, which showed both a food swamp and a food desert and the high accessibility of less healthy food in comparison with healthier establishments. (12,13). According to Glanz et al. and Story et al. there are common drivers related to the deprivation that shape the less healthy food shopping behaviour among residents, and these contribute to weight gain (7,8,14). Although the cluster of causes that lead to obesity is hugely complex and several determinants potentially can influence the eating patterns, the community food environments quality and accessibility might be part of these factors that

encourage inhabitants to eat less healthy food regularly. The drivers of obesity are also closely associated with health inequities so a multi-level approach is needed to tackle obesity (5,6,15). Intervening in the food environments in deprived neighbourhoods is part of the Scottish government new food policy; however, more articulated initiatives are needed to fight against obesity, starting from the roots of poverty (16,17).

Declaration

I hereby declare this thesis was composed by myself and it is my entirely my own work. It has not submitted for any previous application for a degree or professional qualification.

Andrea Fuentes Pacheco

May 2020

Dedication

This thesis is dedicated to my family, friends and Ander.

I will be eternally grateful with my parents, Claudio and Claudia, for teaching me to be perseverant and give me all the opportunities in life

To my siblings Catalina, Sebastian, Maria Jose and my niece Florencia. You have been my best kept secret during the difficult moments.

To my grandparents Pedro, Telita and Ana, for their inconditional support and love

To my uncle Leo and aunt Cecilia for showing me there are no limits to reach the stars

To my friends Natalia, Laura, Nazmy, Evelyn, Dani, Clarissa, Eduardo, Lorena, Alfredo, Anne, Javier, Encarni, Emmy, and Cecilia for their encouragement words and eternal support.

I dedicate this work and give special thanks to my special love. He taught me that nothing is impossible if you put your heart into it.

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Abbreviations

WHO	World Health Organization
SES	socioeconomic status
FAO	Food and Agriculture Organisation
GIS	Geographic Information System
QGIS	Quantum Geographic Information System software
FSS	Food Standard Scotland
km	kilometres
m	metres
mRFEI	Modified Retail Food Environment Index

Chapter 1 – Introduction

This chapter introduces the concepts that generated and shaped this research. The chapter discusses the relevance of community food environments in the obesogenic process and explains the motivations for conducting this study.

In 2018, The First Minister of Scotland, Ms Nicola Sturgeon, said in an interview on the BBC with one of the celebrities of the British food industry, and an advocate for healthy food (1):

"*Obesity is a serious public health issue which cannot be ignored. Evidence shows obese children are likely to stay obese into adulthood and become more likely to suffer health problems such as diabetes and cardiovascular diseases at a younger age*."

This statement indicates the importance of the obesity problem among Scottish children and adults. The condition of obesity has been classified as a pandemic due hit all countries around the world, from the least to the most developed nation and across all age groups, ethnicities and sex (2,3). However, it affects significantly more to low- income nations and populations, evidencing the social inequalities that surround its genesis from the early stages of life (4). Its alarming increasing trend and magnitude level over the last 30 years, the causality network rooted invert and health inequities and the fact that no country in the world has reversed this problem yet, has been made obesity a titan challenge of the 21st century (3,5).

The condition of obesity, regarded in some literature as a disease (6), is described as one of the most complex health problems of modernity due to its multi-causal aetiology (6,7). The obesity causality network composed of hundreds of causes that might be implicated in the individual weight gain during every stage of life (3,7). The WHO defines obesity as abnormal or excessive fat accumulation that may impair health and the term "obesogenicity" is frequently used to refer the process of gaining weight which

will end in obesity (2). The condition has been recognized as a risk factor which constitutes a complex metabolic syndrome itself which produces a widespread alteration to an individual's cardiovascular system in the medium to long-term (2,6,7). Being obese increases the risk of developing a wide range of non-communicable diseases such as i) type 2 diabetes, ii) cardiovascular disease, and iii) cancer; thereby contributing significantly to the burden of these pathologies (2,6).

According to the foresight programme, there are 7 clusters of obesity causes: one cluster is directly linked to the environment (7). The environment it is all that surrounds human beings and the setting for human activity. The built environments or also called the human-made environments as cities have been identified as one of the environmental causes of obesity (8) (8,9). Cities include all the spatial elements built to establish human settlements, such as neighbourhoods, urban green areas and all type of public and private infrastructure (9,10). Neighbourhoods are the places where people live and interact, containing residential areas, worksites, schools and other types of infrastructure that people use regularly (8). Thereby the place where people have their homes and buy their food is tremendously relevant due to might have a great influence over resident's lifestyle and health status (11,12). Evidence have described that poor neighbourhoods and their environment can expose people living, working, studying or merely passing there to several risk factors such as pollutants, alcohol, and also different types of high – energy-dense and less healthy food, contributing to health-damaging behaviours and consequently, to the development of obesity and other health problems (11,12). In simple words, when the neighbourhood have a great exposure to high energy dense and less healthy foods it is considered an "obesogenic food environment" due to is promoting obesity among people exposed to the setting (5,8).

From an epidemiological perspective, "exposure" the term used to describe factors to which a person or a group of people come into contact, and that may have an impact on their health" (13). The food exposure within a

neighbourhood is known as the food environment (5). In this case, to be exposed to a poor quality community food environment (higher number of establishments selling poor quality food in abundance usually combined with a lack of outlets offering healthy foods) might have an influence over the "exposed people" and a role in their obesogenicity journey (8,13).

Obesity affects economically disadvantaged people the most in every society (4). They are more exposed and more vulnerable to develop diseases and other health problems due to having more individual biological (poor health profile) and social risk factors (4,14). They have been exposed from early life to structural inequalities such as poverty, low – income, lack of power, poor living conditions, low education level and belong to a minor ethnicity, which amplifies their individual risk factors (4,14).

The constant and prolonged exposure to a poor community food environment and other adverse intermediary determinants as poor living conditions and less healthy food environments drives individual risk factors, causing obesity and a wide range of diseases and in long-term, premature death, lower life expectancy and a higher number of years of life lost by disability. This phenomenon has been defined as the "deprivation amplification effect"(4,14).

Although research about neighbourhoods and its potential impact over residents' health profile started some decades ago (15), there is still a lack of data about their community food environments characteristics and their role in the obesogenic process, especially in deprived urban areas in Scotland. Considering the significant impact, that obesity has over the population and the need to identify and tackle from the roots all the factors that are causing and encouraging it, both, the scientific community and the Scottish government have highlighted the food environments as a research and policy priorities (7,16).

This research focuses on the community food environment in a deprived neighbourhood in Glasgow, Scotland. More research is needed to understand in a more profound way, how community food environments work and to

explain potential mechanisms that contribute to the shape of obesogenicity within the neighbourhoods.

The study develops a foodscape or “food map” within the study area to assess their features and analyse the spatial scope of the community food exposure (17). Globally no country has reversed its estimates of obesity (11). More efforts than ever have to be made to understand the obesity determinants better to design efficient strategies to tackle once and for all the obesity from its unequal roots

Chapter 2 – Research aim and objectives

This chapter presents the research aim, objectives and research questions. It also includes the scope of this study and a summary of each chapter to briefly explain the thesis structure. The objectives of the chapter are:

- to present the aim, objectives and research questions
- to explain how each objective was developed in order to answer the research questions
- to describe the scope of the study
- to provide a summary of the structure of the thesis

As discussed in Chapter 1: a) the scientific relevance of the topic, b) the magnitude of the problem for the Scottish public health and c) the gaps found in the scoping review were all considered in order to formulate six research questions. These questions originated the aim and objectives that guided the present investigation. Additionally, I incorporate a Geographic Information System (GIS), nutritional epidemiology and public health approaches to improve an innovative methodology, which, as far as could be verified, had not been applied before.

2.1 – Aim and objectives

The overall aim is to **establishing a process of mapping the community food environment in a deprived neighbourhood in Glasgow City in order to identify contributors that shape obesogenicity**.

Three objectives guided this research:

- to map the community foodscape of this neighbourhood
- to describe the unique foodscape features
- to assess the physical exposure of the population to healthier and less healthy food sources within the neighbourhood

This programme has been constructed around eight research questions:

1. Which methodologies have been used in previous studies to assess the obesogenicity of community food environments using spatial analysis?
2. What are the physical food sources available to the residents within the neighbourhood?
3. How many of the different types of food sources are there in the areas?
4. Where are these food sources located?
5. What determines their accessibility?
6. What are the general characteristics of food sources?
7. What are the characteristics of healthier and less healthy food sources and how this shape obesogenicity?
8. What are the distributional patterns of these food sources?

The first objective is to produce a map. Due to there was a lack of information about food environments mapping and analysis of their obesogenicity, the first research question was focused on collecting all the methodological data. To answer this question, I conducted a rigorous scoping review that provided the answers to produce a representative food sources map or foodscape and assess the obesogenic potential of the food environment using the spatial analysis. This review allowed me to design the mapping methodology and describe: i) the number, ii) the type, iii) the location of food sources and iv) to assess accessibility of food sources within the neighbourhood; thereby answering the second, third and fourth research questions.

The second research objective is to describe the food sources' features, which provides information to answer the fifth question. I used the spatial and nutritional epidemiological analyses to report the most predominant food sources, identify the distribution patterns and discuss how the food sources exposure shapes the deprived neighbourhood's food culture.

The third research objective is to assess the healthy and less healthy food exposure that let me answer the last two research questions. To do that I re-categorised the foodscape and the database into: a) healthy and b) less healthy groups in order to analyse their predominance and distribution patterns. This approach offered me the chance to analyse the food exposure and the factors that might shape the issue of obesogenicity in the researched area of Glasgow.

The scope of the study comprised the production and spatial analysis of a foodscape to analyse if accessibility and availability of certain type of food may promote an obesogenic behaviour. A foodscape is a map of the food sources, which was specifically designed to visualising the community food environment in a deprived neighbourhood (11,17). The community food environment for this study was defined as all physical outlets or sources of Whitewood neighbourhood that sell or offer primarily or secondarily food to the public (5,9). I mapped the food sources into the foodscape, calculated and analysed the number, type, location and the accessibility of the residents using the spatial analysis. These food sources formed by the food environment of the neighbourhood and for this reason researchers have coined it as “the community food environment” since they are located nearby and within residential areas and are available to the community living, working and studying there (5,9).

As it was described in chapter 1, the characteristics of the built environment in which people make their food choices and the access to different types of food have been suggested as a critical cause of obesity, especially in deprived settings where people with economic constraints have fewer possibilities to buy in more distant places. The theoretical basis of this study relies on the evidence showing that less healthy ready-made food, snacks and products are everywhere and easily available in many establishments selling food primarily or secondarily to other products, located nearby residential areas (5-13). On the other hand, the lack of healthy food offer, which also used to be more expensive, might also, be discouraging purchase and consumption of this type

of food and promoting the frequent consumption of less healthy type of food which also is commonly cheaper (5,8,9). Overexposure of less healthy products and underexposure of healthy ones may influence negatively food shopping behaviour and dietary habits, affecting residents' body weight over time (10-12). Both realities may co-exist together and create a toxic obesogenic food environment for the neighbourhood residents.

For this study, all the physical food sources were included. Although I did not find private gardens or allotments, they might have been considered as part of the community food environment if they would had been open to the public no matter if they sell the products or give it free. I also mapped and described non-traditional outlets such as charitable organisations (i.e. food banks), community centres, street vendors, entertainment related outlets and those selling alcohol (i.e. pubs selling fast casual food, pubs that not sell elaborated preparations but offer processed snacks, etc.). Food banks, pubs and the other outlets mentioned above offer frequently less healthy food and constituted an important part of the food exposure and often they are not mapped remaining invisible in the studies. Measuring less outlets means that only a part of the toxic food environment is often measured, also underestimating the obesogenic exposure.

Online food sources and outlets not open to the public, not selling food or with incomplete data to mapping and/or categorising were excluded from the study. Due to the scope of the investigation was put the focus on the physical food environment, online or delivery food sources were eliminated. The main reason to exclude online food sources were that they were not part of the physical community food environment, which is the scope of the foodscape and the objectives of the thesis. To investigate the influence of the virtual food environment is not part of the study and requires a different methodology. The use of a multidisciplinary approach, including GIS technologies, spatial analysis, public health and nutritional epidemiology, have signified an enormous contribution to the environmental health field. Even the more basic foodscapes have enriched the visualization of the food exposure across

different settings. However, the first step is to develop a methodology to create a more detailed map that represents in a better way the real exposure of the community food environment with more food sources categories. Until now, most of evidence have shown a limited part of the exposure, making invisible a great proportion of food outlets which number, type, location and accessibility create barriers and incentives to buy and consume food. A more complete foodscape and its spatial analysis are primordial to describe the unique features of the community food environment and identify factors that may be inflecting an obesogenic food behaviour. These data will be valuable for policy makers to modify and improve local and national public policies. Specially focused on deprived neighbourhoods were deprived food environments with poor quality food offer are considered an environmental and social injustice that is inequitable and avoidable. Future policies must include in their framework the human right to healthy food, which has been proposed by United Nations as a priority for food environmental policies. The right to adequate food is a legal obligation under international law and must to be considered by Scottish policy makers.

Considering the above, my hypotheses were the following: “foodscapes include a limited type of food sources and by consequence, represent a small part of the community food environment”, and “foodscapes’ spatial analysis do not combine accessibility measures to analyse the obesogenicity of the community food environment”. In combination both design’ problems result in a very poor description of the community food environment and an underestimation of the obesogenic potential that it has over residents’ nutritional status. This underexposure is mainly because there is not a well-developed the methodology to measure and assess foodscapes. These statements led me to propose a third hypothesis: “using the correct methodology, Parkhead possesses an obesogenic food environment”.

2.2 – Structure of the PhD

The present thesis is structured in nine chapters, which are guided by the research objectives.

Chapter 1 presents: a) an overview of the topic, b) the relevance of the thesis and c) explains the reasons and rationale for conducting this research.

Chapter 2: a) shows the research questions, which originated the aim and objectives of the study and b) describes the structure of the thesis.

Chapter 3 provides a theoretical framework to understand: a) the complexity of the obesity problem, b) the role of food systems and c) the community food environments in the obesogenic process.

Chapter 4 provides: i) a rationale to analyse the most relevant literature at the global and national levels, which explores the relationship of community food environments and obesity as well as additionally: ii) analysing the various methodologies used in the selected studies.

Chapter 5 describes: i) the research design, ii) the methodology and iii) the ethical approval used to conduct the study.

Chapter 6 reports the main results of the study focusing on: a) the general features of deprived food environments and b) the analysis of the healthy and less healthy exposure.

Chapter 7 explains the main improvements made in the research methodology and compares them with the methodology used in the studies analysed in the scoping review.

Chapter 8 discusses the results and compares them with the evidence analysed in the literature and scoping review. It also identifies the most relevant governmental policies implemented by the Scottish government, as

well as making recommendations a) to improve food environments and b) for future research.

Chapter 9 presents the conclusion of the research as well as the researcher's personal reflections.

Chapter 3 – The issue of obesity: the roles of food systems and community food environments in the obesogenic process

The chapter analyses the obesity problem and the role of food systems and food environments in the obesogenic process. The objectives of this chapter are:

- to describe the obesity pandemic and its causes
- to comprehend the contribution of deprived community food environments and food systems to the obesogenic process.

The chapter is divided into three sections.

Section 1 describes the magnitude, trend and causes of obesity

Section 2 explains the way in which food systems are connected with neighbourhoods and how this is constructed into a specific food environment.

Section 3 provides an overview of the way in which the community food environment influences the obesity environment and obesogenicity.

3.1 – The obesity pandemic

3.1.1. Magnitude, trends and causes of obesity

The obesity pandemic has been increasing dramatically on a global scale since 1975 (2). According to the World Health Organization (WHO), over 650 million adults were obese in 2016, representing 13% of the world's adult population (2). Future projections show that if these trends continue, the global prevalence will surpass 18% in men and 21% in women by 2050 (2). The increasing trend has particularly affected high and upper-middle-income countries that have reached high levels of industrialization and urbanization level. However, a growing number of low and middle-income countries are now also dealing with this pandemic alongside their additional burden of malnutrition (18–22). While the prevalence of obesity is rising across all the

population segments, the highest figures have been observed in the most disadvantaged social groups (18–22). Obesity is now a major global health challenge especially among those who suffer socioeconomic disparities across the globe (18–22).

Obesity is also a significant public health problem in the UK. The figures reporting obesity levels have trebled in the last 30 years, achieving the highest prevalence in Western Europe (16). According to the UN Food and Agriculture Organization, the UK has become the "fat man of Europe." Scotland has one of the worst obesity records in the developed world and one of the highest rates of all OECD countries, where only the USA and Mexico have higher levels (21). Analyzing the trend in the last two decades, adult obesity in Scotland has steadily increased from 17% in 1995 to 28% in 2018 (16,23). The Scottish Health Survey showed that 65% of all adults (aged 16+) were overweight (including obese) in 2018. It was also noted the average body-mass index (BMI) increased from 27.1 kg/m2 in 2003 to 27.7 kg/m2 in 2018 (16,23). These figures exceed UK's overweight prevalence that reached 61.7% in 2016 and put this condition among one of the biggest threats to public health in the 21st century in Scotland (16,23). Following the global pattern, Scottish men and women in the most deprived areas are more likely to be obese than men and women in the least deprived areas (16). In fact, Ellaway, Anderson and Macintyre reported in their study that Glaswegians living in the most deprived neighbourhoods were significantly shorter, and had greater BMIs and central obesity (waist circumferences and waist-hip ratios) in comparison with those living in the least deprived neighbourhoods (24).

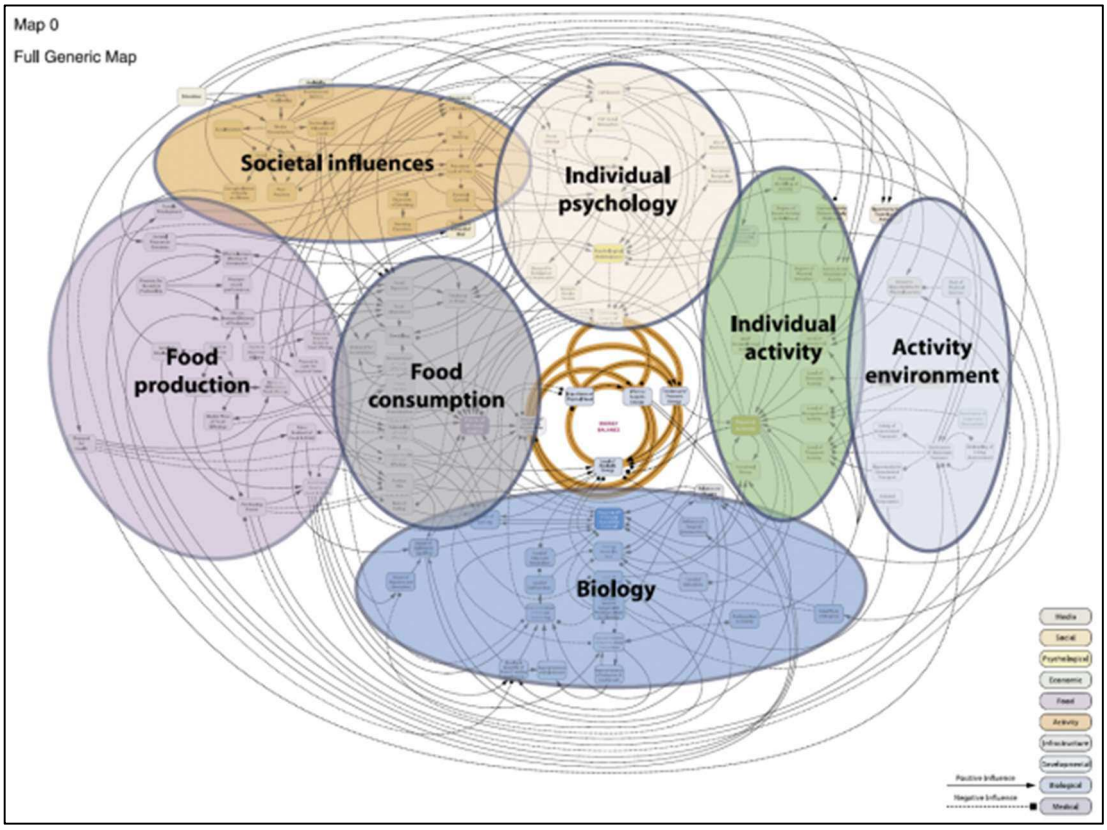
As in the rest of the world, the condition of obesity has a massive impact on health costs and population health. In 2007, it was estimated that the total cost of obesity to Scottish society was more than £457 million; by 2030 the estimates of the direct cost of obesity to NHS Scotland will have doubled (16,23). In 2010, the Scottish Public Health Observatory (scotPHO) estimated that: a) 47% of type 2 diabetes, b) 36% of hypertension, c) 18% of myocardial infarction, d) 15% of angina and e) 12% of osteoarthritis could be attributed to

obesity (23,25). Considering all this background, the Scottish Government declared that the condition of "overweight and obesity bring with it a risk of disease and a cost to society that is avoidable and if it is not stopped it will directly impact on our ability to achieve sustainable economic growth"(16,25). The analysis made by the government's Foresight Programme highlighted that Britain had become an obese society where being overweight is "normal" (7,8). The projections show that over half of the UK adult population could be obese by 2050 (7,16,21). This alarming figure displays the major socio-economic challenge the country will face in the next decades. According to the report "Measuring Up" published in 2013 for the Academy of Medical Royal Colleges, this is the most significant public health crisis facing the UK today (26).

The condition of obesity is produced by an imbalance between energy intake and energy expenditure over sufficient time; a situation which produces a harmful fat accumulation. In other words, there is a life style involving a higher consumption of high-energy dense and unhealthy food, usually combined with a decrease in the intake of nutritious and low-energy dense food, as well as in physical activity levels (2,18). These variables are negatively reinforced by many factors that impact on eating behaviour and the process of gain weight (7). As described in Chapter 1, these factors are at the same time strongly magnified by inequity from early childhood (4,16,21). Inequity acts from the broader socioeconomic context, a structural impact (income, education, ethnicity and gender) over people and generates through the life course, differential exposure to a wide range of risk factors of those most vulnerable (such as low incomes, single parents, elders and children) (4,14). It also exposes them to different experience within the health system and, as previously mentioned in the previous section, different consequences from obesity. Altogether they lead to a compounding disadvantage, which is unfair and avoidable (4,14,22).

Secondary contributors to the obesity condition are multiple, and they are interrelated in a multifaceted system of determinants (7,8). Such contributors are also part of the overall contextual and intermediary determinants of health.

Figure 1. Obesity system map



Source: Foresight Tackling Obesities: Future Choices (7).

As can be seen in Figure 1, the obesity system map, is defined "as the sum of all the relevant factors and their interdependencies that determine the condition of obesity for an individual or a group of people" (7). It was elaborated and published by the Foresight Programme in 2007 and comprised of clusters of intermediary or secondary causes: i) physiological, ii) psychological, iii) social, iv) food production, v) food consumption, vi) individual activity and vii) environmental (7,8). Physiological cluster involves the genetic predisposition to develop obesity and biological risk factors. Psychological cluster includes: individual psychological drivers for particular foods, eating behaviour, and physical activity patterns and preferences (7). Societal influences, such as

culture, media and peer pressure, incorporate the impact of society on eating behaviour and physical activity patterns. In this framework, food systems involve clusters related to food production, food consumption and its influence over the environment (7). **Food systems and the built environment** especially in deprived areas can promote obesity and amplify the effect of individual low socioeconomic and biological circumstances: particularly 'risk'. This classification highlights the complexity involved in the causality network (4,7,14). According to this model, there is more than one pathway to becoming obese. How a person becomes obese will depend on how many individual and environmental risk factors are interacting, together with the prolongation of the exposure during their lives (7,8). However, as Figure 1 sets out, the environment always plays a crucial role as a determinant.

3.1.2. The role of high and medium energy food densities in weight gain

To comprehend the fat accumulation process **and the environmental influence over food consumption** it is necessary to introduce first some basic concepts. The Center for Disease Control (CDC) and the British Dietetic Association (BDA), define energy density as the amount of energy or calories in a particular weight of food (27,28). This density is presented as *'the number of calories in a gram (kcal/g)'* which comes from the energy supplied by macronutrients such as: a) fat, b) carbohydrates and c) proteins, as well as alcohol (27,29). The composition of foods affects energy density values. The higher the total amount of energy of foods and the easier the nutrients' transformation into fat, the greater will be fat accumulation levels (53). While each nutrient contributes to the total energy, fat doubles the number of calories compared to proteins and carbohydrates per gram (27–29). Despite alcohol not being considered as a food nutrient, it contributes significantly to the weight gain when alcoholic beverages are consumed regularly (27,29). Regarding absorption, simple carbohydrates can be easily metabolised and transform into fat, considerably faster than proteins. Water and fibre lower energy density, contributing in volume but not in calories (27,29). They also decrease the absorption velocity of the rest of the nutrients, helping to slow down the

nutrients' accumulation into fat. It is possible to calculate the energy density by dividing the number of calories that each serving contains by the weight of a portion in grams (27).

The BDA has four categories to classify energy density of foods: i) very low energy density when a portion reaches less than 0.6 kcal/g; ii) low energy density when the food has between 0.6 and 1.5 kcal/g; iii) medium energy density when products and preparations have between 1.5 and 4 kcal/g and iv) high energy density when foods surpass 4 kcal/g. Foods with a high proportion of water and fibre tend to have a lower energy density, whereas those foods which are higher in fat, tend to have a higher energy density (28). Examples of low and very low dense energy food are: a) fruits and vegetables, b) wholemeal/wholegrain varieties of cereal, pasta and rice, c) beans, d) porridge made with water, e) baked potatoes, f) low fat vegetable soup and g) pulses (27,28). Furthermore, products high in proteins but with low or medium fat and sugar include: a) most fat-free and low-fat dairy products, b) fish, c) seafood, d) chicken, e) turkey and f) lean red meat (53-55). Medium-energy dense foods commonly include a wide range of healthier preparations, which are moderate in fat and complex carbohydrates, such as: a) baked or grilled salmon, b) mashed potatoes, c) stews, d) low fat cheese, e) jams and f) bread (27–29). While small portions of fast foods i.e. pizza and bakery products as, cakes should be also be regarded as medium energy dense (27,29,30) yet, the standard portion size is much larger than the requisite small portions, and they are frequently filled with fat and/or refined sugar, meaning that are considered as high-energy density foods (27,28,30).

Products with a high content of fat and/or simple carbohydrates are considered as high-energy dense foods, such as “fast foods” that are often referred to as “empty calories” products (27,30,31). These types of products are frequently processed by the food industry, with very low protein, fibre and micronutrient contents. They are commonly offered in large portions that surpass the body’s capacity to metabolise and spend the energy, resulting in a sustained body fat accumulation over time (27,30,31). The most common fast foods include: a)

sugary drinks, b) fried chips, c) sandwiches, d) paninis, e) traditional burgers with and without high-fat cheese, f) pizza, g) large hot-dogs, coupled with sauces such as mayonnaise and curry with sausages. Snacks including chocolates, sweets, bakery products (27,31). Traditional British food include fried fish, haggis, diverse preparations with pork-rich in fat, and some of the components of the famous Scottish breakfast (which contains eggs, back bacon, sausages, buttered toast, roasted tomato, baked beans). Not only does the amount of calories matters in term of healthiness and energy balance, the quality of foods and artificial components also can prevent or promote the obesogenic process (7,8,31). Extremely low, low and some medium energy-dense foods are associated with innocuous diets, low sodium content and are rich in antioxidants. Lower energy-dense food can act as a health protection factor because these foods are not only moderate in calories and rich in nutrients; such foods are also high in substances that detox and maintain the cardiovascular system and defend the body against obesity, NCDs and cancer (7,27,30,31). When the population achieves, or has access to, a nutritious diet as described above, that population is described as having high levels of **food security** (32). Food security is defined “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (32,33).

High energy-dense foods are the opposite of the above. Fatty and sugary processed products not only contain an excess of energy but in many cases they are also high in: i) sodium, ii) colourants, iii) saturated fats iv) trans-fats and simple artificial carbohydrates (27,31). All of these ingredients are risk factors associated with NCDs and the diseases mentioned above. They have been associated with the pro-inflammatory process, which means that these dietary components can modulate key pathways to inflammation; furthermore they not only contribute to body fat accumulation but can subsequently lead to insulin resistance, diabetes and atherosclerosis (6,27). In this current research case, it has been proposed that these foods not only possess high energy-density but are also unhealthy (6,30,31). Commonly unhealthy foods and high energy-dense foods are treated as synonyms; however, products with higher

density are not necessarily or always unhealthy (6,8,28,31). For this reason, the two concepts should not be perceived as identical, even if many products qualify as such. When a population 'achieves', or is consuming, an unhealthy diet the situation is described as involving a population with high levels of **food insecurity** (32,33).

3.2 – Food systems, neighbourhoods and food environments

3.2.1 Food systems and their interaction with community food environments

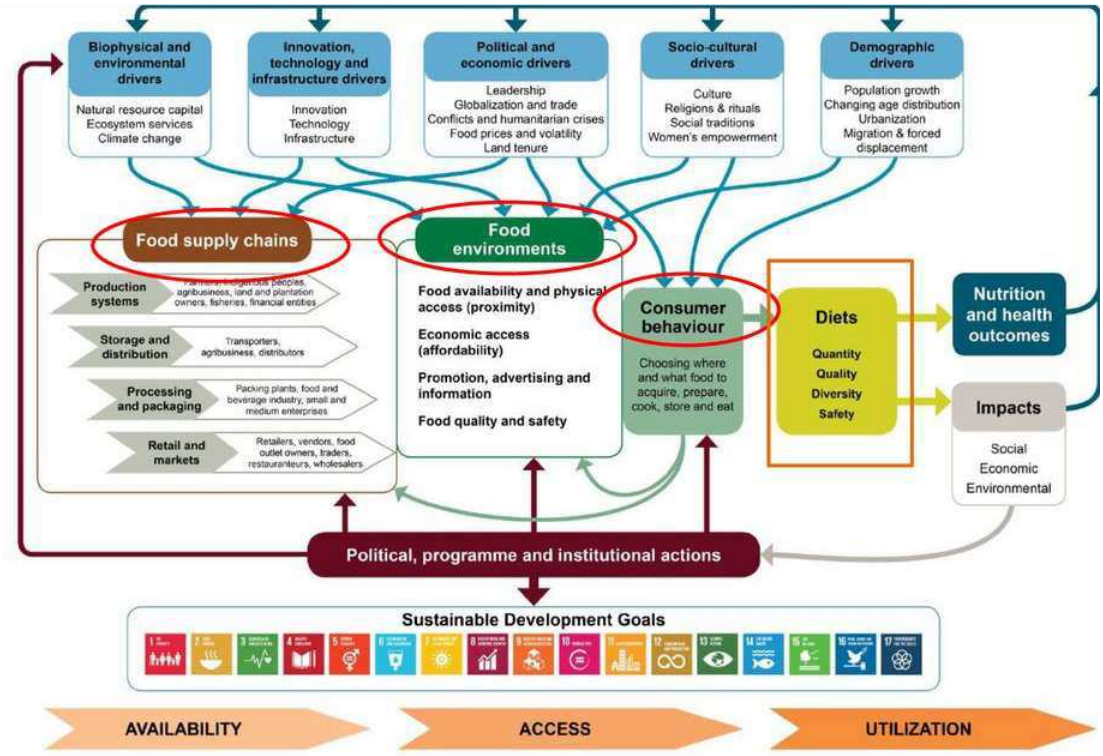
The food system is made up of a dynamic and complex food production and consumption chain (33,34). According to the Food and Agriculture Organization of the United Nations (FAO), food systems involve all the processes needed to feed people and "encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded" (33,34).

The food system is in constant development within cities, providing food supply to neighbourhoods through established and emerging food environments. **Food environments** are defined as "the collective physical, economic, policy and sociocultural context that influences people's consumption choices and nutritional status" (33,34). Neighbourhoods are part of the built environments and have their own food environments where food systems become a dynamic entity through the distribution, availability, marketing, safety and consumption of foodstuff (24-26).

Although traditionally on a much smaller scale, sometimes urban settings also produce food, such as vegetables and fruits in urban gardens. As displayed in Figure 2, each part of the food system is also influenced by the described socioeconomic and political contexts at micro and macro-levels and inequities,

impacting in the local community food environments (34). Disparities in each step of the food chain are present across the globe (34,35).

Figure 2. Conceptual framework of food systems for diets and nutrition



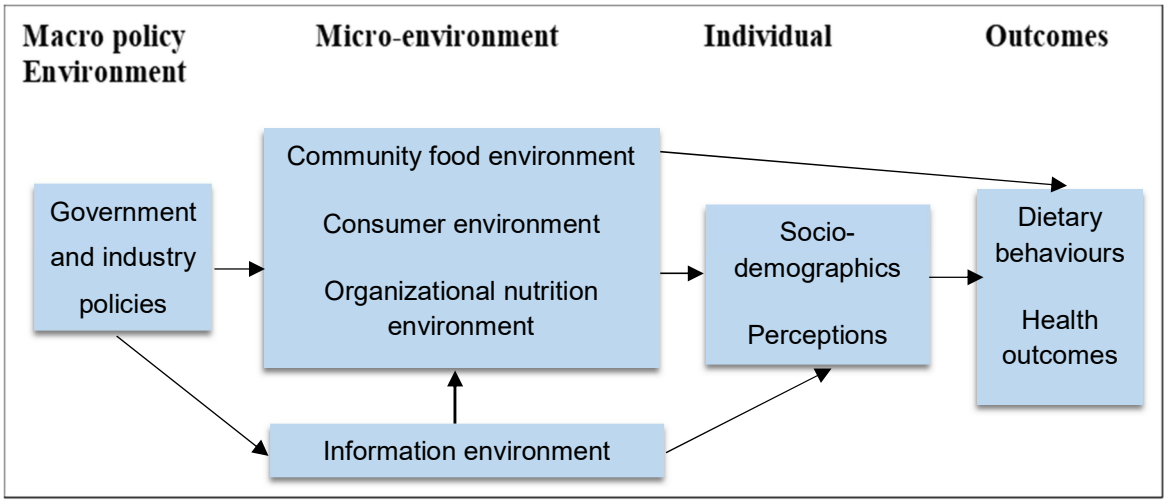
HLPE. 2017. Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (34).

One relevant example is the low-cost production of processed products at the expense of nutritional value available in the unprocessed form of those foods. As a result, these caloric products are affordable, cheap and appeal to the palate of the consumer, yet offer limited health benefit (they have added salt, fat, and sugar that are be prejudicial for health if they are frequently consumed) (4,34,35). Although the food industry and governments are aware of this situation, the regulation of this type of products is still deficient and processed foods continue inundating the most humble neighbourhoods (35,36). An incredibly easy and fast profusion of these products to community food environments ensures that these foods are available everywhere, while healthier foods can be more difficult to obtain and more expensive (35,37).

3.2.2 Food environments subtypes

Figure 3 displays a conceptual framework for the study and comprehension of food environments (38). According to Glanz et al. (2005) the food environment is composed of four sub-environments influencing dietary behaviours and health outcomes at different levels: i) community, ii) consumer, iii) organisational and iv) informational (media and advertising) (37,39).

Figure 3. Conceptual framework for the study of nutrition environments



Source: Geographies of obesity: Environmental understandings of the obesity epidemic. Adapted from Glanz et al. (2005) (38)

The **community food environment** refers to the number, type, location, and accessibility of food sources within a location in which people live, study and/or work (37–39). The **consumer food environment** involves the availability and quality of: a) healthy options, b) price, c) in-store promotion and d) provision of nutritional information within the retail food outlets. The **organisational food environment** is focused on access and availability of food within specific micro-settings such as homes, schools, and workplaces. The **informational food environment** is related to the media and advertising influence on food choices within the other three types (37–39). These sub-environments interact with each other and with the food system, influencing the food behaviour of local consumers. In spite of the four sub-types having a relevant role within the food environment dynamic, the community and consumer environments have

been recognised as high research priorities when taking into account their potentially far-reaching effects regarding health outcomes (37,38).

3.3 – Obesogenic community food environments: a combination of food deserts and food swamps

As was mentioned in the previous section, the community food environment includes the presence and distribution of food sources, expressed by: i) number, ii) type and iii) location of establishments (37,38). The combination of these three characteristics determines **accessibility and availability** to purchase food provisions within the neighbourhood. Availability depends on the variety of food provision within outlets and variety is directly related to the type of food source (37–39). Physical access depends on the number of food retail stores and their distance from the places where people eat food, prepare food or procure food. Commonly this variable is calculated measuring walkable distance from the centroids of spatial units of analysis to food sources, with the former often being represented by residential areas, schools and workplaces. The theoretical basis of this thesis relies on the that availability and accessibility influence barriers and opportunities that facilitate or hinder healthy food purchasing and a healthy food intake (37,39–41). Both are determinants of food choices and the nutritional status of residents and people buying foodstuff in a given area. These factors are also interacting with an important variable that is part of the consumer food environment and which strongly influences purchasing behaviour: food prices (37,40,41). Food costs are mainly regulated by governments, while the global market can also become another major determinant of food buying behaviour (37,40,42).

Depending on the food quality offered within the establishments, the availability and accessibility of food will either have a positive or negative impact over the nutritional status of any given population (37,38,43). In a positive way, the preposition is that if numerous outlets are offering a wide range of healthier and affordable options, and/or are closer to places where people live, study and work, then the population concerned will have better and easier access to those foods (37,41,43). This combination facilitates and

encourages nutritive purchases and the maintenance of healthy and energy-balanced dietary behaviour, embracing a high food security level over time (33,37,41,43). Many affluent neighbourhoods have these 'healthy' food environments and are often referred to as 'food secure' areas (37,43).

However, in a negative way, issues of availability and accessibility can also facilitate the consumption of poor quality food, as well as promoting an obesogenic food environment. Swinburn and Egger (2002) described these factors as "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations"(5,44). Commonly refers to urban areas such as neighbourhoods that combine two different types of food exposure that are strongly influencing eating patterns in a damaging way (5,44).

The first one is related to the barriers preventing the purchase of healthy and lower energy-dense food. If a smaller number of healthier outlets are selling more expensive products in the neighbourhood, and/or they are located further from the organisational food environment, such factors will decrease the opportunities to shop for these healthier types of products, thereby negatively influencing diet quality (5,37,40–42). This scenario has been referred to as a **'food desert'**; an environment first identified in Scotland to describe communities that have limited access to affordable and nutritious foods (45,46). Currently, the term has evolved to refer to "areas with lack of access to affordable fruits, vegetables, whole grains, low-fat/non-fat milk or dairy alternatives, and other foods that make up the full range of a healthy diet" (45–47). This definition is concordant also with 'food insecure' areas where there is a lack of nutritious food on offer to the residents (33). Lack of availability and access to nutritious foods by default might encourage the consumption of other high- energy dense food products, resulting in as well as promoting unhealthy eating behaviour.

A **second scenario** has been referred to as **a "food swamp"**, which are defined as "areas in which large relative amounts of high-energy-dense snack and foods, inundate healthy food options." (48). These types of foods are

supplied by the food system; besides being highly accessible and available they are strongly promoted by macro and micro forces as food prices facilitate their frequent intake (5,37,42,48). ‘Highly accessible’ means a major number of outlets offering these products, located conveniently near to the consumers. ‘Highly available’ refers to a major offer within the stores, often for a more convenient price (37,41,48). ‘Food swamp’ areas are in most cases present in deprived neighbourhoods and may be considered as ‘food insecure’ areas (5,42,48). In industrialised countries living in a post-nutritional transition stage, studies have described how economically, and physically disadvantaged people often rely on the purchase of food in nearby and ‘walkable’ areas rather than spending money on public or private transportation. It means they have limited mobility for food shopping and therefore, on a daily basis, they depend on the opportunities they have within their neighbourhood (10,26,28). Residents’ limited spatial mobility, together with the combination of ‘food deserts’ and ‘food swamps’, reinforced by attractive prices and in-store promotions, all serve to increase individuals’ exposure to obesogenic food, leading inevitably to unhealthy eating patterns and a steady increase in a person’s body fat over time (28-32).

Though some studies have found no relationships between community food environments and obesity (5,37,40), a substantial number of studies point to evidence that deprived food environments encourage an obesogenic food behaviour in the people living and/or working there. Drewnowski and other authors have identified that individuals under economic constraints, in low-income neighbourhoods, frequently shop and consume high energy-dense foods, which are generally much cheaper than more healthy food products (4,21,42). Such cheaply priced offers are very attractive to the population purchasing in the neighbourhood, because the food is ready to serve, tasty, affordable, abundant and there is no need to spend time shopping further (37,42,48)

Researchers have also proposed that even if residents have a good access to healthy food, the less healthy or high energy-dense food by itself promotes a

higher consumption of such food because consumers are on the receiving end of higher exposure, low prices and the food's attractiveness (42,48). New insights in neurobiology show that humans adapt readily and quickly to environments with poor - quality food choices. Processed foods, especially those with an increased palatability, drive people to reward themselves by consuming that higher energy-dense food (7).

As it was mentioned in chapter 1, considering the great increase in the magnitude, trend and projections of the obesity problem in Scotland, is a priority for the Scottish government and researchers in the field to generate evidence about different causes of the obesity and take actions in terms of public policy to tackle this condition from the roots (5,8,9). Environmental causes of obesity, including obesogenic food environments, still remain hidden and underestimated due to the lack of data about them (5,11). More than ever, it must be a governmental priority describing in more detailed food swamps and food deserts and analyse spatial factors that they may act as obesogenic drivers. The focus must be put in build up evidence at local level, especially in deprived neigbourhoods, where the figures of obesity are considerably higher and where the international evidence has pointed out as perfect inequitative scenarios for obesogenic environments (4,21,42).

Until now, food swamps have been poorly described, assessing a limited part of the exposure and food deserts have not being measured in most of the strudies. As it was mentioend in chapter 2, the lack of data remains invisible this relevant information which is important for policy makers to understand and plan future policies. A foodscape measuring both scenarios, food swamps and food deserts enriches the problem visualisation due to observing the obesogenic food environment in all its extent would allow policy makers observe the level of concentration of less healthy foods and healthier foods and the distribution patterns to plan more effective interventions to improve the quality and access of the community food envitonment and the other food environments subtypes.

In the last 15 years, Scotland has made an effort to create public policies to tackle obesity and although all the initiatives were implemented, none of them have been successful (1,9). Future interventions need to take into account the valuable information generated by foodscapes to produce multilevel and multisectorial policies, which undertaken local and national levels and different sectors and partners (1,9). Deprived food environments are also strongly related to environmental inequalities and poverty, which are enrooted in the structural causes of modern diseases, including the obesity (42). National policies based on the social determinants framework have been suggested as the best scenario to tackle this condition and so many others. In other words, it is needed to consider different approaches at the moment to design multilevel policies, considering at least socioeconomic, education, housing and other structural sectors to improving living conditions and reducing poverty of the vulnerable population (11,9,42).

The next chapter provides the evidence relating to the relationship between communities' food environments and obesity at international and national levels. The reviewed studies analyze the potential mechanisms in which community food environments might act as an obesity driver in the UK and other regions with similar socioeconomic contexts.

Chapter 4 – Scoping review: the relationship between community food environments and obesity

Chapter 4 presents a scoping review focused on the relationship between community food environments and obesity. In this review, I aim to understand what are the key research gaps around food mapping of obesogenic environment. The review explores the evidence relating to the association between community food environments and obesity at both international and national levels. It is also presented a revision of the designs and spatial analysis employed to develop the methodology of the thesis.

Three objectives of the scoping review were to:

- Understand the nature of the association (type and correlation) between community food variables and obesity.
- Identify the most used GIS measures to assess the community food environment.
- Identify the food sources used as a proxy of the community food environment, as well as which types are associated with healthy and less healthy foods.

The chapter is divided into seven sections:

Section 1 starts with an introduction to the review and highlights the main empirical and methodological contributions.

Section 2 describes the methodology used to conduct the search, collect and then analyse the data.

Section 3 depicts the general characteristics of the sample.

Section 4 discusses the results considering the nature of the found associations.

Section 5 analyses the methodological analysis of the studies used to explore and represent the community food environment.

Section 6 summarises the main characteristics of the sample and reviews the findings.

Section 7 describes the gaps and limitations of the available evidence and then presents the justification for developing this thesis.

4.1 – Introduction

Obesity is a relevant and preventable public health problem related to societal inequalities and consequences of modern urban lifestyles (4,7,42). International and national studies have yielded evidence gained from exploring, for nearly two decades, the association between community food environments and obesity. Previous systematic reviews conducted in North America have shown mixed findings, with some confirming the positive and negative influences of the community food environment over the residents' obesogenic process (40,49–52). However, it should be noted that studies were unable to establish a causal relationship between community food environments and obesity mainly because of the cross-sectional research designs. These investigations have also used a heterogeneous methodology, selecting different types of food outlets to represent the community food environment, as well as various GIS measures to assess that environment's impact on obesity.

The analysis of the findings allowed the understanding of the **type of association** (causal or only associated) and **type of correlation** (positively or negatively associated with the residents' obesity). This background permitted me to test two of my hypotheses and to develop the methodology to mapping and examine the type of community food environment and their influence over obesity in the UK and across different regions with comparable socio-economic development level contexts. This initiative was essential in order to complete the rationale of the thesis and identify gaps in the literature to support the justification of the study.

The scoping review provided valuable indicators relating: a) to the variables most commonly used to represent the food exposure and b) to the types of food outlets selected in previous studies to represent the healthy and obesogenic community food environments. Additionally, the flaws and limitations in the studies' identification and analysis helped to improve the collection and analysis of these data; thereby, facilitating the design of this current research.

4.2 – Review methodology

I carried out a scoping review using methods and strategies associated with systematic reviewing. Comprehensive search strategies were developed across two relevant databases and grey literature, drawing on the methodology developed by Cobb et al. (2015) and applying the systematic review protocol I published in 2018 (49). The systematic review protocol was designed for a larger revision that aimed to assess the evidence of all type of food sub environments and obesity. For this research purposes, only the search and analysis of the community food environment and obesity was developed in the scoping review. The reason was that this research is focused specifically on that food sub environment and undertaken the others would lose the focus and clarity of the thesis theoretical framework.

I registered the protocol in PROSPERO (International Prospective Register of Systematic Reviews) in 2017 (ID: CRD42017068193). (Note: the protocol is shown in Appendix 1. Cobb et al. (2015) explored the relationship between the local food environment and obesity in the U.S. and Canada (49,53). This current scoping review has updated Cobb and extended the geographical scope to incorporating studies conducted in the UK, Ireland, Australia and New Zealand that have assessed the dimensions of community food environments.

As this research was conducted in the UK, this researcher chose comparable countries in terms of: i) development level, ii) nutrition transition stage, iii) socio-economic distribution, iv) magnitude and v) trend of obesity at the national levels. These selected 'matching' countries have produced the most

substantial amount of evidence about this association and have the highest figures and the worst projections of obesity in America, Western Europe and Oceania. The obesity prevalence in these six countries (US, Canada, UK, Ireland, Australia and New Zealand) is concentrated in disadvantaged urban areas, and all of them are experiencing the same post-nutritional transition, influenced by a strong, globalised and industrialised food market (21,49,52).

4.2.1 Eligibility criteria

This review has included all observational epidemiological peer-reviewed studies that have assessed community food environments inside neighbourhoods. Also included are calculations made around a participant's residence as a proxy for residential areas (cohort, longitudinal, case study and cross-sectional) with group-level data and individual level-data from more than 200 people. This sample size threshold was used by Cobb et al. (2015) who identified that studies with a smaller sample would be statistically underpowered for the detection of a significant association between the variables (49). I included populations regardless of age, sex or ethnicity, with the review including articles published from 1990 to May 2019. The initial cut-off year was adopted by Cobb and other literature reviews, the rationale being that before the last decade of the 20th century very little data appeared in this field (15,39,49). I included only studies written in English.

This scoping review is informed by the following GIS measures: a) the number and density (counts/population, counts/area) of food sources and b) proximity (walkable and direct distance from residential areas to the nearest food sources). I excluded studies using 'activity – space methodology' due to such models evaluating community food environments outside the participants' neighbourhoods, as well as commonly using a small (less than 200) sample. Also excluded was literature exclusively looking at: i) individuals with major pathologies, ii) pregnant women, iii) homeless populations, iv) breastfeeding women and v) participants who had physical limitations. These conditions independently affect subjects' nutritional status. Individuals with grade 3 obesity were excluded due to grade 3 being the most severe stage of obesity;

according to the evidence there are other physiological causes involved in that status, which is also referred to as ‘morbid obesity’.

4.2.2 Search strategy

I developed a preliminary search scan in MEDLINE to identify and build a list of indexes and free terms (Appendix 2). I agreed the final list of search terms through a consultative process with the review team; as well as clinical, social science colleagues and a senior librarian from the University of Edinburgh. I applied comprehensive search strategies to improve search accuracy and retrieved a significant number of articles studying the relationship between community food environments and obesity I selected three types of academic resources to expand the search: i) large databases, ii) grey literature and iii) reviews’ references lists. I searched the Pubmed (Ovid) and Embase (Ovid) databases. Both were selected considering the databases used in other reviews as they contain the largest number of articles related to the research topic. I hand-searching eight systematic reviews, including Cobb et al. (2015) (49). I also searched in Opengrey Europe and the Grey Literature report. Additionally, I checked the reference lists of selected articles to retrieve additional studies.

4.2.3 Study records

I retrieved study references from i) databases, ii) grey literature and iii) hand searching to the Mendeley reference manager software library. I also used the programme for the screening and de-duplication process. I carried out the extraction under senior researcher supervision (LG). After a review of previous data collection strategies, I selected and extracted data items into an Excel file containing the data extraction format. Extracted features are displayed in Table 1, including: a) relevant information about studies’ description, b) design, c) exposure, d) outcomes, e) analysis, f) key findings and g) limitations.

Table 1. Data categories included in the extraction form

Study description	Design	Exposure	Outcome	Findings

Authors Title Aim/ objective Setting Study design Publication year Age range	Exclusion criteria Food sources definition	Data source Year of collected data Type of food environment variables Neighbourhood definition Measured food sources	Reported outcome Outcome definition Self-reported or direct measures Statistical analysis	Key results Limitations

I collated data from each study into the form and elaborated a final database of all formats using a customised Excel sheet. I piloted the extraction form before its full use in the review. During the pilot, I extracted and jointly reviewed the first ten articles, with a second reviewer (SF). I obtained the remaining items under supervision (LG).

4.2.4 Outcomes and prioritisation

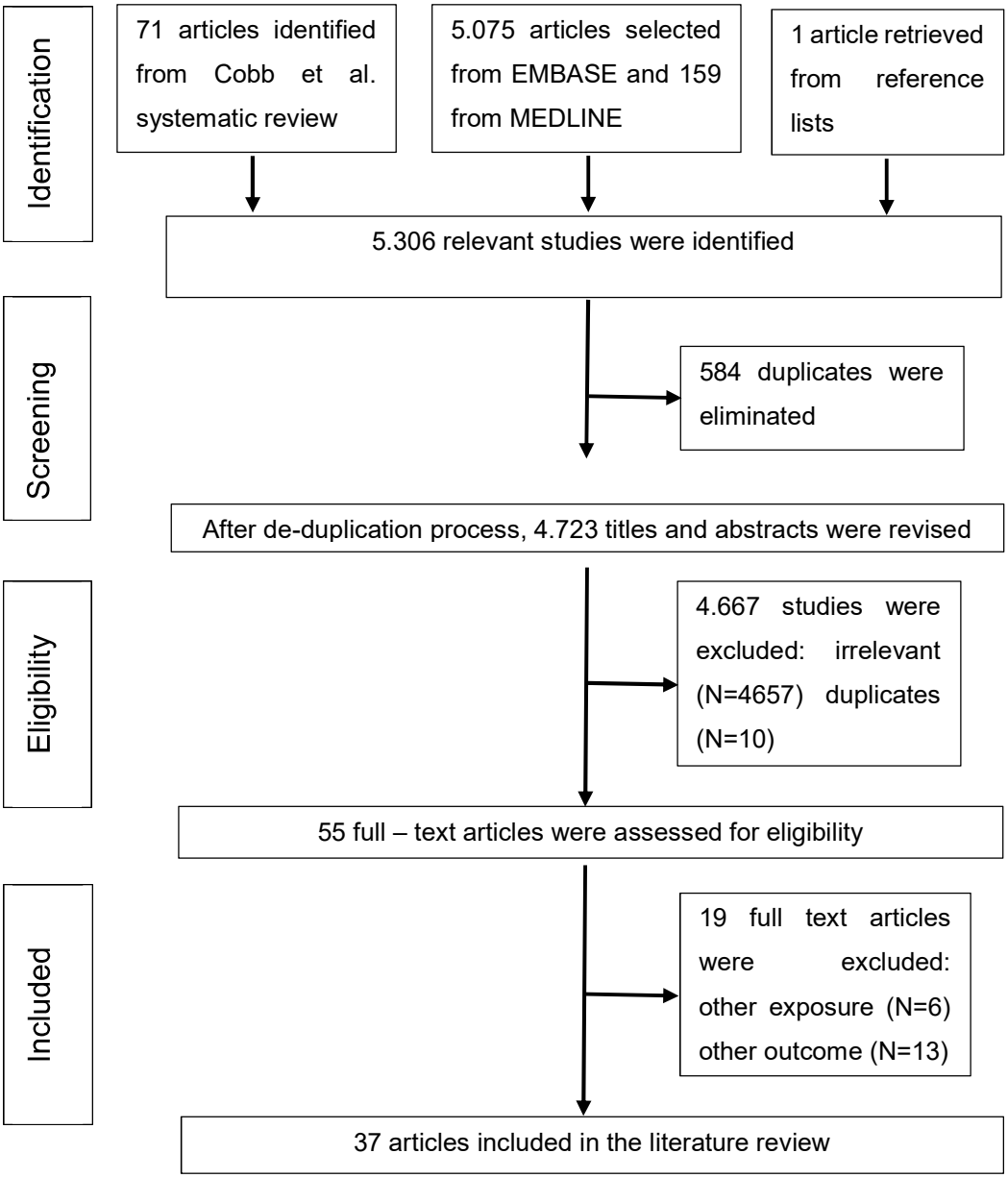
The primary outcome is obesity. The diagnosis of this pathology follows the criterion established by WHO to classify *obesity* as being a body mass index (BMI) over 30 kg/m². The secondary outcome was central obesity, represented by waist circumference and waist-to-hip ratio and was proposed to be included if the primary outcome was not available. This situation did not happen with any study.

4.3. General features of the sample

I described identification, screening, eligibility and selection processes using a PRISMA diagram (54) (Figure 4). I identified 5,306 potentially relevant publications from the Cobb et al. review, MEDLINE and EMBASE databases and reference lists. After a records de-duplication process (N=584), I identified 4,722 studies that potentially accomplished the inclusion criteria, I reviewed 55 full-text articles to reach the final sample, composed of 37 articles (55–91). I selected 78.3% (N=29) from the Cobb et al. (2015) review sample (55–70,73–75,77–82,84,86–88). I obtained the remaining 19% of the records from online

databases (N=7) (71,72,76,83,89,89,90) and 1 (2.7%) from reference lists (85).

Figure 4. PRISMA Diagram



The general features of the articles are shown in Table 2. Almost 95% (N=35) of the studies have used a cross-sectional design, while only 5% (N=2) have a longitudinal design. Even though the studies were published between 2004 and 2016, most of them 78.9% (N=30) were concentrated between the years 2009 and 2013. Positive associations were found in 45.9% of the studies (N=17), and predominately negative in 29.7% (N=11) of the sample, whereas only 13.5 % (N=5) explored both positive and negative associations in parallel. Finally, non-significant associations between these variables were found in

24.3% of the studies (N=9). Regarding the geographical scope: i) 70.2% (N=26) studies were conducted in the U.S., ii) 16.3% (N=6) in Canada, iii) 10.8% (N=4) in the United Kingdom and iv) 2.7% (N=1) in Australia. Approximately 72.9% (N=27) of the sample was focused on the adult population, including two studies containing only containing women *participants*. The remaining proportion had a mixed sample and only 4.3% (N=2) of the publications using a children sample.

Table 2. Overview of the articles included in the scoping review

Author and year	**Correlation**	**Country**	**Age group**	**Food outlet exposure**	**Exposure measures**	**Neighbourhood definition**
Longitudinal studies						
Gibson, 2011 (55)	positive	US	adults	S, GS, C, FF, FSR	density	zip code area
Leung, 2011 (56)	positive & negative	US	adults	S, GS, C, FF, FSR, FM	density	0.25 and 1 mile buffer around participants' homes
Cross-sectional studies						
Burdette, 2004 (57)	null	US	children	FF	proximity	participants' address
Morland, 2006 (58)	positive & negative	US	adults	S, GS,C	prevalence	census track area
Lopez, 2007 (59)	null	US	adults	S, FF	density	Zip/postal code area
Li, 2008 (60)	positive	US	adults	FF	density	census block area
Babey, 2008 (61)	positive	US	adults	RFEI Index	ratio	0.5 mile buffer around participants' homes
Morland, 2009 (62)	positive & negative	US	adults	S, GS, C, FF, FSR	proximity	Census track area
Spence, 2009 (63)	positive	Canada	adults	RFEI Index	ratio	800 and 1600 m buffer around participants' homes
Oreskovic, 2009* (64)	positive	US	children	FF	proximity density	400 m buffer around participants' homes
Oreskovic, 2009* (65)	null	US	children	FF	proximity	400 m buffer around participants' homes
Rundle, 2009 (66)	negative	US	adults	healthy and unhealthy groups**	density	805 m buffer around participants' homes
Zick, 2009 (67)	negative	US	adults	G&S, C, FF, FSR	prevalence	Census block area
Truong, 2010 (68)	positive	US	adults	PFEI Index	ratio	Census track area
Ford, 2010 (69)	null	US	adults	S, GS, G&S, C	density	1, 3,5 and 10 miles buffer around participants' homes
Poliou, 2010 (70)	null	Canada	adults	G&S, C, FF	density	500 m and 1.5 km buffer around participants' homes

Author and year	Correlation	Country	Age group	Food outlet exposure	Exposure measures	Neighbourhood definition
Black, 2010 (71)	negative	US	adults	S, FF, R, C, FB	density	Neighbourhood (United Hospital Fund (UHF) geographic unit)
Fraser, 2010 (72)	positive	UK	children	FF	proximity density	Output area (OA)
Bodor, 2010 (73)	positive	US	adults	S, GS, C, FF	proximity	2 km buffer around participants' census tracks
Prince, 2011 (74)	positive	Canada	adults	G&S, C, FF, FSR, SS	density	Neighbourhood (Ottawa neighbourhood study)
Mellor, 2011 (75)	null	US	children	FF, FSR	proximity	0.1, 0.25, 0.5 and 1 mile buffer around participants' homes
Macdonald, 2011 (76)	null	UK	adults	F&V, S, C	proximity	participants' address
Cerin, 2011 (77)	negative	US	adults	G&S, C,FF,FSR	prevalence proximity	1 km buffer around participants' homes
Dubowitz, 2012 (78)	positive & negative	US	adults	G&S, FF	density	0.75, 1.5 and 3 miles buffer around participants' homes
Prince, 2012 (79)	positive	Canada	adults	G&S, C, FF, FSR	density	neighbourhood (Ottawa neighbourhood study)
Saelens, 2012 (80)	negative	US	adults & children	G&S	density	census block area
Hutchinson, 2012 (81)	negative	US	adults	S, GS	prevalence	0.5, 1, 2 km buffer around participants' homes
Drewnowski, 2012 (82)	negative	US	adults	S	proximity	participants' address
Hobbs, 2012 (83)	null	UK	adults	S, C, FF	density	2 km buffer around participants' homes
Roth, 2013 (84)	negative	US	adults	G&S, FM	density	Zip/postal code area
Miller, 2013 (85)	negative	Australia	children	FF, healthy food outlets***	proximity	800 m and 3 km buffer around participants' homes
Chen, 2013 (86)	positive	US	adults	FF, FSR	proximity	0.5 miles buffer around participants' homes
Hattori, 2013 (87)	positive & negative	US	adults	S, GS, C, FF, FSR	density	1, 1.5 and 3 miles buffer around participants' homes

Author and year	Correlation	Country	Age group	Food outlet exposure	Exposure measures	Neighbourhood definition
Bader, 2013 (88)	negative	US	children	GS, FF	density	400 m buffer around participants' census track
Larsen, 2015 (89)	negative	Canada	children	FF, healthier food outlets****	proximity density	1 and 2 km buffer around participants' homes
Burgoine, 2016 (90)	positive	UK	adults	S, FF	density	1 mile buffer around participants' homes
Le, 2016 (91)	null	Canada	children	R, GS, FF, C	proximity density	500 and 800 m buffer around participants' homes

Abbreviations: S=supermarkets; GS= grocery stores; C= convenience; FF= fast-food outlets; FSR= food service restaurants; G&S= group of grocery stores and supermarkets; F&V= fruits and vegetables stores; FM= farmers' markets; R= any restaurants; FB= food banks; SS=specialty stores; RFEI Index= Retail Food Environment Index; PFEI Index= Physical Food Environment Index

* Both studies used the same sample population and year

**Healthy and unhealthy groups= healthy (supermarkets and fruit & vegetable markets); unhealthy (fast-food restaurants, groceries, pizzerias, bakeries, candy and nut stores)

***Healthy food outlets= grocery stores, supermarkets and butchers

****Healthier food outlets= bake shop, bakeries, butchers, fish shops, food store (convenience/variety)

4.4 – Findings related to the association of community food environments and obesity

4.4.1 Type and correlation of the associations

Analysing the type and correlation of the associations between community food environments and obesity is important in order to comprehend the nature of the association and the impact of the food environment on the obesogenic process. In terms of **the type** of association, 95% of the investigations have incorporated a cross-sectional design, while only 5% (N=2) of them have used a longitudinal design. Both longitudinal studies were undertaken in the U.S., using a sample of adults (55,56). Studies employing both types of research designs showed statistically significant associations, an outcome which suggests access to food outlets in the neighbourhood clearly affects participants' nutritional status. However, considering the type of design, and in concordance with the findings and discussions undertaken in previous reviews, a causal inference could not be confirmed (92). The main limitation of cross-sectional is that the authors measured 'exposure' and 'effect' at the same time. Consequently, the investigations cannot assess food sources exposure over time and confirm any cause / effect relationship, as it is unclear if the effect came before or after the exposure (92).

To present the results of this review I have divided the publications into three categories: i) studies that predominately found positive associations, representing most of the sample, followed by: ii) studies that found predominately negative associations and iii) studies that confirmed both types of association. As described Table 1, 75.6% (N=28) of the studies have found at least one positive and/or negative association between community food environments variables and obesity (55,56,58,60–63,65–68,71–73,73,74,77–82,84,86,86–90). By comparison, 24.3% (N=9) of the studies showed mainly null results (57,59,64,69,70,75,76,83,91). Only 13.5% (N= 5) of the studies found both positive and negative types of associations (56,58,62,78,87), in parallel, within the same neighbourhoods. The investigations included in this scoping review

used either children and/or adults and were conducted in different regions of the world (U.S., Canada, UK and Australia). Positive associations were confirmed between a high exposure to less healthy food sources (commonly measured via fast-food outlets as a proxy of food availability and a higher risk of obesity. Negative or inverse associations were found in two situations, after adjusting for individual and socio-demographic variables: a) between a higher exposure to healthier food sources (supermarkets, grocery stores) and a lower risk of obesity, b) between a low exposure to healthier food sources and a higher risk of obesity. A total of 21.6% of the studies were conducted in deprived settings, due to it is well-known obesogenic environments are strongly developed in low income neighbourhoods. These publications have showed that the risk of obesity was higher in deprived neighbourhoods.

4.4.2 Negative associations between community food environments and obesity: the effect of healthier food environments and food deserts on the obesogenic process

Eleven cross-sectional investigations conducted among children and adults, in the U.S., Canada and Australia have shown predominately negative associations between different types of healthier food outlet measures and obesity (66,67,71,77,80–82,84,85,88,89). However, other studies which found mainly positive associations, also obtained inverse relationships between these two variables (56,58,62,78,87).

In the US, Drewnowski (2012) found an inverse relationship between proximity to **supermarkets** and obesity (82). Saelens et al. (2012) and Black (2010) (PR=0.95, PR for z-score=0.88; $p<0.001$) have found the same relationship (71,80). After adjusting for individual and socio-demographic features, higher density and proximity of supermarkets in residential areas were associated with lower obesity rates or with lower odds of being obese. Morland et al. (2006) found a lower prevalence of obesity in areas with at least one supermarket (58). Cerin et al. (2011) and Zick et al. (2009) found that greater numbers of **grocery stores** (smaller supermarkets) were associated with

lower obesity rates (67,77). Prince et al. (2011) related lower odds of obesity (OR=0.72, 95% CI:0.56, 0.91) with higher densities of **sit-down restaurants** in deprived settings (74). Dubowitz et al. (2012) and Roth et al. (2013) also corroborated this negative association with grocery stores, as in the case of Morland et al. (2009) who found a lower prevalence of obesity in the areas with at least one **sit-down restaurant** (62,78,84)**.** Similar findings were obtained by Larsen et al. (2015) in Canada, where they reported (after adjusting for socio-demographic and individual variables) a higher density of **healthy food outlets** (bakeries, butchers, fish shops, and grocery stores) and close proximity to a supermarket decreased the likelihood of obesity in children living in low-income neighbourhoods (89). Similar results were obtained by Rundle et al. (2009) and Hutchinson et al. (2012) who found that the higher the density of **healthy food outlets** (supermarkets, fruit and vegetable markets, and natural food stores) the lower was the population's level of obesity (66,81).

Miller et al. (2013) in Australia also showed that an increase in the number of **healthy food shops** (supermarkets, fruit and vegetables stores, butchers) within 800 m of a child's household was associated with a significantly reduced risk of being obese (85). Each additional healthy food outlet was associated with a 19% decrease in the children's' odds of being or becoming obese. Other studies yielded mixed results: Leung et al. (2011) found that access to **produce vendors** and **farmer's markets** within 1-mile network buffer was inversely related with girls' obesity after 3 years (OR 0.22 95% CI 0.005, 1.06) (56). Following the same line Roth et al. (2013) found that an increase in density of farmer's markets was independently associated with lower odds of obesity (84). Both types of food outlets offer a greater availability of fresh fruits and vegetables and other healthy foods.

The study from Bader et al. (2013) was the only one, which showed that a greater density of **fast outlets** predicts lower odds of obesity for adolescents (88). In this case, according to the authors there were a number of factors that could affect this conclusion. Among the reported flaws are: i) a small representation of the neighbourhood area (400 m around the centroid of a

census track), ii) the sample distribution was not distributed homogeneously among census tracks and iii) the fast food outlets sample was composed of some sub-types, but not the whole range.

Apart from the Bader et al' study, the evidence from different contexts shows that a higher number, density and proximity of healthier community food environments is associated with lower rates of obesity, and the likelihood of developing obesity, in both adults and children. These findings are concordant with studies that showed better access to healthier food sources enhanced the availability and access to more nutritive and fresh products. As a consequence, such conditions promote a resident's dietary intake improvement. In their reviews both Glanz et al. and Story reported that several studies found positive associations between a higher density of supermarkets and healthier food intakes (37,39). Morland et al. and Cheadle et al. in the U.S. have also reported that diets of residents improved when supermarkets in their neighbourhoods offered healthier options (93,94). Morland also revealed that fruit and vegetable consumption increased with each additional supermarket in the census tract (58). This finding is concordant with Jilcott Pitts findings, who found that women used to shopping in farmers' markets have a higher and more frequent intake of fruits and vegetables, together with a higher food security level (P<0·001), when compared to those who did not shop in these types of outlets (95). In the U.K., Barret et al. found that a greater density of healthier specialty stores (greengrocers, health food stores, farm shops and butchers) in neighbourhoods and near schools was associated with higher diet scores among children (β=0·025 SD/store: 95% CI 0·007, 0·044) and (96). These associations suggest that the community food environment might also act as a protector of the residents' nutritional status, so influencing healthier shopping habits and improving diets and ultimately resulting in healthier BMIs for the residents (43,95–97).

As I described in the previous chapter, a lower presence of supermarkets and other healthier food sources, such as grocery stores and farmers' markets, might negatively affect diet quality and increase obesity figures; thereby

suggesting that food deserts can contribute with the obesogenic process. This influence is concordant with findings from Laraia et al., who demonstrated that pregnant women living four miles away from a supermarket were more likely to have a lower diet quality, after controlling for socio-economic levels and the availability of smaller food sources nearby (97). This finding also suggested that diminished access to these food sources decreases the quality of diet; ultimately affecting the individual's BMI in a negative direction.

Different studies have confirmed the presence of **food deserts** and an inverse relationship with obesity in some of the deprived neighbourhoods that were researched. In the US Bodor et al. reported 26% of the participants did not have any supermarkets within their neighbourhoods (73). Lopez et al. also found 48.9% of the studied neighbourhoods did not contain any supermarkets (59). The findings from Morland et al. showed the mean distance to the nearest supermarket in their sampled environment was further than the nearest fast food outlet (1.77 vs. 1.39 miles) (58). The same group of authors also reported 56% of the participants lived in an area with at least one fast-food restaurants, whereas only 26% lived in an area with at least one supermarket (62). In the UK, Macdonald et al. found that despite 73% of the study participants living within 500 m of a general store, only 32% lived within 1000 m of a fruits and vegetables store and 46% within 1000 m of a supermarket (76). Other reviews conducted in North America have also confirmed that food deserts are most common in low-income neighbourhoods (37,39,40,43,82). Mushi-Brunt et al. found that nearly 50% of the children living in high poverty did not have any grocery store within their neighbourhood (98). Furthermore, in their review Byker et al. noted that residents travelled from between 9.7 to 27.4 kms just to reach a farmer's market (99).

In the UK, food deserts are a reality although not every poor neighbourhood has one, they are present in many of them. In 2018, the Social Market Foundation published research titled "What are the barriers to eating healthily in the UK?" It was estimated that 10.2 million people in the UK live in food deserts, of which 1.2 million live in deprived areas (100). Glasgow reported 8

of the 10 most deprived food deserts in Scotland, confirming that the food access issue is a dramatic reality among Glaswegians (100). Mills and Wright found in a qualitative study that 93% of interviewed residents preferred to buy food at supermarkets and confirmed they feel satisfied with their availability, but they only could reach the establishments by 15 minutes' drive or via public transport from their households once a week (101). All the analysed evidence suggests that food deserts are currently present in the country and lack of access to healthy foods might acts as an obesity promoter, influencing less healthy shopping and the poor diets of the residents.

4.4.3 Positive associations: contribution of neighbourhood food swamps on the obesogenic process

Twelve cross-sectional and two longitudinal investigations conducted among children and adults, in the U.S., Canada and the UK have shown predominately positive associations between different types of less healthy food outlets and obesity (55,60,61,63,64,68,72–74,79,86,90).

A longitudinal study from US and was conducted by Gibson et al. in 2011, using a child 6 years old population. It was found that a higher density of **convenience stores** increased the odds of obesity among adolescents aged 14 – 22 years old (OR 1.45 95% SD 5.19), confirmed via a 2 years follow-up (55). Cross-sectional studies have also shown that a greater density and proximity of this type of outlets is associated with higher rates or risks of obesity. Prince et al. predicted that increased density of convenience outlets was associated with higher probabilities of excess weight and obesity (OR= 1.17, 95% CI 1.11, 1.72) in Canadian adults (74). Bodor et al. found in the US that a greater proximity to these outlets was predictive of higher obesity odds in adults in deprived areas (OR 1.01 95% CI 1.00, 1.02) (73).

Evidence also points to higher **fast food** density being associated with greater obesity odds. For example, Oreskovic found such an association in children and adolescents in low-income settings in the US ($p<0.001$)(65). Prince (OR=1.38, 95% CI: 1.11, 1.72) obtained similar findings in Canadian adults

(79). Same *humble* significant association was found by Chen et al. who noted a marginal effect of the fast food density within 0.5 miles of participants' residences and obesity levels (P<0.05)(86). However, in comparison, the study conducted by Hattori et al. with a larger buffer of 3 miles around participants' residences, noted that the density of fast food outlets was significantly associated with higher odds of obesity in adults (P<0.05)(87). Both studies also used the main franchises in their respective cities: however, neighbourhood size may have influenced significant results, informed by the expanded exposure area.

Li et al. also showed significant positive associations between a high density of fast food outlets (the main franchises in Portland) and a greater likelihood of being obese in comparison with neighbourhoods with lower densities of these outlets (OR=1.8; 95% CI=1.006, 3.496)(60). The same authors, in a second analysis of residents aged 50 to 75 years old, found that one standard deviation (SD) increase in the density of fast-food outlets was related with a 7% increase in cases of individuals being overweight and obese (p< 0.01). Bodor et al. reported that closer proximity to fast food outlets predicted a greater likelihood of neighbourhood residents' obesity (OR 1.01 95% CI 1.00, 1.02)(73). Morland et al. also found that a higher prevalence of obesity was associated with at least one franchised fast food restaurant in the neighbourhood (PR=1.36 95% CI= (1.05, 1.77)(62).

Fraser et al., in a study conducted in Leeds, UK, noted that a greater density of fast food outlets was significantly associated with childhood obesity (p<0.02)(72). The research team also found a significant relationship between neighbourhood density of fast food outlets and higher deprivation level (p<0.001)(72). Similar findings were obtained by Burgoine et al. in Cambridgeshire, UK, where it was found that higher fast-food density was associated with greater odds of members of the adult population developing or displaying obesity (p<0.05)(90). Macdonald et al. although obtained mainly null findings, confirmed that higher density of general stores and supermarkets

was associated with lower rates of obesity among residents (0R= 1.80; CI:1.09-2.96; P< 0.021)(76).

In Canada Prince et al. found that with every additional specialty food store (including specialised food types, meat stores, seafood outlets, fruit and vegetables outlets, bakeries, candy and nut outlets, dairy stores, etc), women were almost two times more likely to be overweight or obese (OR=1.77, 95% CI: 1.33, 2.20)(74). Three studies have used indexes to measure the food healthiness of the environment. For the studies that used the **RFEI,** Babey et al. found that people living in lower income neighbourhoods, with a higher ratio of less healthy/healthy food outlets (fast-food outlets and convenience stores/supermarkets, farmers' markets and produce stores), have a greater prevalence of obesity (61). Babey et al., together, with Spence et al. in Canada also found that approximately one in four adults with neighbourhood RFEI over 5.0 is obese, compared to one in five when the RFEI is below 3.0 (61,63). Spence et al. have also shown that the odds of a resident of being obese were significantly lower if they lived in a neighbourhood with the lowest RFEI level (healthier environment) versus the highest score (less healthy), regardless of the neighbourhood's socio-economic level. Truong also obtained similar conclusions using the Physical Food Environment Index (**PFEI)** (68). He found that a higher ratio, corresponding to a less healthy PFEI, was associated with a greater risk having a high BMI ($p<0.001$) and/or being obese ($p<0.01$).

The revised literature in US, Canada and the UK, has confirmed that a higher presence, density and proximity to different, less healthy, food outlets can increase the rates and odds of obesity across different countries and age groups. This relationship also existed in the UK in adults and children living in deprived neighbourhoods. Only one study associated a higher prevalence of specialty stores, (which included some healthy food stores i.e. fruits and vegetables outlets and fish shops) with higher obesity. Nevertheless, the proportions of each type of outlet could be different and these data are not available. As explored in chapter 3, this is concordant with the explanation that different authors have proposed, where closer proximity to, and higher density

of, less healthy food sources, improves and enhances the availability of cheap, calorific and high energy-dense food which facilitates low-income residents' purchasing and consumption of these types of products(7,37,42). In the long term, this constant exposure to poor food choices may contribute to unhealthy dietary patterns and a sustained body weight shift, increasing the odds of being obese(5,8,51). This explanation is concordant with findings from Fraser et al., who confirmed that in 13-15 years old British children in some urban areas, increased access to high-energy dense food was associated with higher consumption of these foods. In the U.S (72). Hickson et al. found that a higher density of fast food outlets was associated with higher energy intake among African American adults younger than 55 years (102).

According to the findings, food swamps were also detected in the neighbourhoods. In the US, Hattori and Bodor et al. found a greater proportion of these two types of outlets compared to supermarkets (73,87). Rundle et al. in a study conducted in New York also showed that the density of unhealthy food outlets was much higher than density of healthy food outlets (66). Oreskovic confirmed that low-income towns have a greater density of fast-food outlets and obesity rates among children aged 2-18 (64). Babey et al. found that the average RFEI is 20% higher for residents living in lower-income neighbourhoods, when compared to those residents in higher-income residential areas (61). This score gap means that the community food environment was less healthy in deprived areas when compared to wealthier ones. Prince et al. in Canada found that density of fast-food sources (1.24 ± 2.20) and restaurants (0.97 ± 1.79) were the most abundant food sources per 1000 people by neighbourhood in comparison with the lower proportion of grocery stores (0.12 ± 0.15)(74). In Australia, Miller et al. found that the density of fast-food shops was 2.2 km² in comparison to healthy food sources, which only reached 0.8 km² (85). Finally, in their UK analysis, Fraser et al. also confirmed that deprived neighbourhoods have a greater density of, and proximity to, fast- food outlets (72).

In the U.K. a significant number of studies that were not included in this review, because they only explored the community food environment but not its relationship with obesity levels, reported that food swamps are present in low-income urban areas. Cummins, Gibson, and Burgoine among other authors, have found in low-income settings there are high numbers of establishments selling these types of caloric and less healthy foods(55,103,104). These establishments include fast-food outlets, popular takeaways and convenience stores. Food swamps are close to households, schools and workplaces and offer a wider range of high energy dense options at a minimal price (37,48,104). Macdonald et al. also confirmed in Glasgow the most deprived neighbourhoods presented the greatest density of food retailers per 1000 residents whilst the least deprived had the lowest density (76). Macdonald et al. also confirmed that the density of food outlets increased in parallel to the levels of neighbourhood deprivation in Glasgow: the greater the deprivation the greater the number of outlets. Convenience stores and butchers had the highest density in comparison with other type of sources. Cummins et al. and McGuire et al. showed a higher density of McDonald's and other fast-food outlets in deprived areas, compared to other wealthier neighbourhoods in England, Scotland and Wales(105,106). Maguire et al. analysed the density of takeaways and the spatial distribution in Norwich, England between 1990 and 2008 and noted that the density increased across the city, and was significantly higher in poorer neighbourhoods at all time points (106). Nevertheless, the gap in density of these outlets, comparing different socioeconomic status, rose across the study period. Blow et al. also found higher concentrations of takeaways in low income areas in Manchester (107). Finally, although Fraser et al. used a setting located in an affluent region, they found a positive relationship between increasing deprivation and: i) higher BMI SD scores, as well as ii) a greater likelihood of children between 13-15 years old of being obese (72). In North America, Lee et al. reported that children living in deprived neighbourhoods are more likely to have greater access to fast-food outlets and convenience stores compared to those children living in less deprived areas (91).

Findings related to the influence of less healthy food environments and food swamps over residents' obesity are concordant with previous evidence that better access to less healthy food sources inundates the food environment with a greater availability of cheap, ready-to-serve, high-energy dense food (48). Better access and availability of less healthy foods facilitates low-income residents with an incredibly attractive, easy and fast purchase option to: i) a wide range of products and snacks, ii) to unhealthy dietary patterns and iii) a sustained increment in weight over time (7,8).

4.4.4 Positive and negative associations: contributions of food deserts and food swamps to the obesogenic process

The five studies that found positive and negative associations within their neighbourhoods were all conducted in the US (56,58,62,78,87).

Leung et al. found in their longitudinal study that higher neighbourhood density of convenience stores per square mile was associated with greater odds of obesity in girls (OR 3.38 CI 95% 1.07,10.68) and higher density of produce vendors / farmers' markets within a 1- mile buffer of a girl's residence was inversely associated with obesity (0.22, 95% CI 0.05, 1.06) (56). Morland et al. showed a higher prevalence of obesity when the neighbourhood had at least one convenience store with a gas station (PR=1.31, 95% CI=1.07, 1.60) and a lower prevalence when areas had at least one limited service restaurant (PR=0.58, 95% CI 0.50, 0.87) or at least one specialty food store (62). The same group of authors noted similar positive associations between fast foods outlets and obesity in American adults, informed by data from the 'atherosclerosis risk in communities' study (PR=1.16 95% CI=1.05, 1.27) (58). They also observed an inverse relationship between the presence of supermarkets and lower prevalence of overweight, obesity and hypertension in residents (PR=0.83, 95% CI=0.73, 0.92). Dubowitz et al. confirmed that a higher density of fast foods was related to greater odds of obesity among American women, 50 to 79 years old (OR 1.04; 95% CI= (1.02, 1.07)(78). The researchers also noted that the high availability of grocery stores and supermarkets was associated with higher odds of neighbourhood residents

being obese (OR=0.95; 95% CI= (0.93, 0.98), P < 0.001). Finally, Hattori et al., with a larger buffer of 3 miles around participants' residencies, noted that the density of fast food outlets was significantly associated with higher odds of obesity in adults (P<0.05)(87). However, inversely the higher density of large supermarkets within the 3.0 mile buffer was associated with lower obesity rates.

The positive and negative associations were similar to the studies mentioned in previous sections that evaluated the associations separately. The reviewed studies used the numbers of convenience stores and fast foods to represent the less healthy food outlets and the numbers of supermarkets and farmers' markets to measure healthy exposure. These findings suggest that food deserts and food swamps co-exist in different deprived neighbourhoods and probably, if authors measure both, their parallel presence and the synergy between them would be more documented

4.5 – Findings related to research design and the methodological approaches

4.5.1 Most representative food sources used in the studies

As displayed in Table 2, the most commonly studied food sources chosen to represent the community food environment were fast-food outlets, (N=26) (55–57,59,60,62,64,65,67,70–75,77–79,83,85–90), followed by supermarkets (N=20) (55,56,58,59,62,69,69–71,73,74,76,77,79–84), grocery stores (N=18) (55,56,58,62,67,69,70,73,74,77–81,84,87,88,91) and convenience stores (N=14). In minor proportion appeared full-service restaurants (N=10) (55,56,62,67,74,75,77,79,86,87), farmers' markets (N=3) (56,66,84), any type of restaurants (N=1)(91), fruit and vegetable outlets (N=1) (76) and food banks (N=1)(71). Fast food outlets mainly included the most popular multinational franchises such as McDonald's, Kentucky Fried Chicken (KFC), Subway, and Burger King. In a minor proportion, some authors decided to add in this category, local takeaways. A small number of studies also incorporated fish and chip shops, local burger restaurants and small pizzerias.

As proxies of healthy food exposure, authors have selected mainly **grocery stores and supermarkets**. Some publications (N=9) assessed a combination of (G&S)(67,69,70,74,77–80,84) both whereas other (N=5) studies created a “healthy food outlet category” (66,84,89). Healthy groups incorporated supermarkets, grocery stores, general stores, fruit and vegetable stores, farmers’ markets, bakeshops, bakeries, butchers, fish shops and food stores (convenience/variety)(66,85,89). Grocery stores were operationally defined as ‘smaller and less varied supermarkets that are bigger and more varied than convenience stores’(55,56,58,62,67,69,70). Additionally, some studies grouped two or more outlet categories in their data analyses.

The most used food sources, representing exposure to less healthy food, were **fast-food outlets and convenience stores**. Explored less often were: i) full service restaurants, ii) any type of restaurants, iii) specialty stores and iv) food banks. Within the ‘convenience store classification were included: a) corner outlets, b) gas stations shops and c) pharmacies. Among fast food sources, the majority of the studies have included main chain fast food outlets such as KFC and McDonalds as well as: a) pizza shops, b) fast food restaurants, c) burger and chicken outlets, d) pita and sandwich shops, e) ethnic fast food restaurants, f) food courts, g) coffee shops, h) hot dog carts, i) ice cream/yogurt vendors and j) donut shops. A few studies incorporated local takeaways, such as those delivering Chinese, Indian, Thai, Middle East and Italian offerings (66,85,88).

Analysing all types of food sources that authors have selected to explore within community food environments, it is notable that there are only limited data and description sources relating to deprived community food environments. Within deprived neighbourhoods are other types of food sources that are interacting with the residents and influencing their diets and are important to measure and visualise. Examples of that are food aid sources, such as soup kitchens, or betting/gambling shops, some of which also offer food. This lack of research assessment almost certainly underestimates the public’s exposure to

inadequate food sources and creates an invisibility of these food sources that can contribute to a poor diet in an important way.

In the case of healthier food sources, as it is described above, just a few outlets were measured and in a separate way. The **supermarkets** offer a wide range of less healthy products at good prices, but they also offer the widest range of healthy products at the lowest cost. For this reason, these establishments are the most popular representatives of healthier food sources. However, not all the supermarkets have the same food distribution proportions of healthy and less healthy food. Only one study reported a more accurate sub-classification due to some of the sub-types; in particular, discount supermarkets have a higher proportion of less healthy food sources and should therefore: a) be classified differently and b) analysed separately.

Grocery stores occupy the market space between supermarkets and convenience stores. Those stores have been incorporated as the healthier proxies, since the availability of the healthier foods offered is reasonably good (93). The case with restaurants is similar, as authors often did not report any differentiations, other than between full service and other types of restaurant. This limitation restricted the identification of the real exposure and misclassified sub-types of restaurants that can be considered healthy and/or less healthy, with consequent limitations in the follow-up data analysis. In the case of the rest of the shops, the studies did not mention why the authors selected the outlets featured. In the case of fruit and vegetable stores and farmers' markets, to classify them as healthy outlets might be justifiable considering the high proportion of fresh and low energy dense food they sell (41,43,96,108). Fish shops and butchers offer a mixture of high and low energy dense products (109,110). However, according to the Independent fishmongers study conducted in 2005, fishmongers also provide a good availability of different types of traditional fresh and frozen fish and sometimes, exotic fish, which have low to medium calories and are considered nutritious products (109). On the other hand, these venues can also sell fish and meat pie, and other ready-made fatty dishes. Bakeries and bakeshops, while

offering basic staples such as bread, also offer high and medium-energy foods such as pastries, donuts and cakes. From this researcher's perspective, it is unclear why those outlets were included as healthier sources. Furthermore, food deserts have been measured only by the presence, or lack of, supermarkets; thereby restricting the identification of other outlets selling nutritious food.

Convenience stores and fast foods outlets have been identified in this scoping review as the most popular representative sources of exposure to less healthy food. **Fast-food outlets** were mainly represented in the studies by national and well-known franchises, with only a few studies incorporating fish and chips, local burger shops and small pizzerias. More concerning is the fact that almost all of the studies excluded other types of shops such as: i) takeaways, ii) street vendors and iii) local restaurants. Fast-food sources generally have a higher availability of processed high-energy dense products and in most such outlets this type of food is sold at very low prices in large portions (102,111). For this reason, these types of outlet were the most frequently chosen to represent exposure to less healthy foods. Next in choice were **convenience stores**, which also provide a great offering of caloric products but which are more related to snacks and processed products rather than ready-to- serve food, as in the case of fast-food restaurants.

4.5.2 GIS measures used to analyse the community food environment

The most common GIS measures used in the studies were density and proximity to food sources, followed by simple counts and community food environment quality indexes. In this scoping review, the studies use one or more of the following variables: a) 10.8% (N=4) of the studies used a simple count (58,67,77,81), b) 37.8% (N=14) used proximity measures (57,62,64,65,72,73,75–77,82,85,86,89,91), c) 56.7% (N=21) density (55,56,59,60,64,66,69–72,74,78–80,83,84,87–91). Only 5.4% (N=2) of the studies employed the Retail Food Environment Index (RFEI) (61,63) and 2.7% (N=1) used the Physical Food Environment Index (PFEI) (68).

Authors calculated proximity by measuring the walkable distance from households to the nearest food sources by type(s). They assessed distances using different GIS software with the exception of one study that assessed direct distance. Density was assessed by summing the total number of food sources within neighbourhoods or by a number of residents within residential areas, for the different types of food sources. RFEI calculated the proportion of 'healthiness' offered by the community food environment by the ratio between less healthy food outlets (fast food outlets and convenience stores) and healthy food outlets (grocery stores, including supermarkets, produce vendors and farmer's markets) (61,63). The PFEI calculated the proportion of less healthy food sources (fast-food outlets, convenience stores and small outlets) in comparison to the general food outlet exposure (a selection of food outlets, including supermarkets and produce vendors) (68).

4.5.3 Other methodological considerations

Different neighbourhood definitions and buffer area sizes determined the calculations of density, proximity and presence. The use of census tracks and other administrative boundaries might not represent the residents' real neighbourhood shopping area that constitute a limitation. Whilst the use of buffer areas with different sizes, i.e. small as 0.25 and others very large i.e. 3 miles, constitutes another limitation due the use counter intuitive areas could lead to underestimate the exposure.

The use of food outlet datasets, without direct field validation, could introduce information bias, due to the food business lists not being updated (government lists) and/or being incomplete (commercial) in vulnerable neighbourhoods. Misclassification of food outlets into healthy and unhealthy categories can affect the magnitude of the exposure and the strength of associations between community food environment variables and obesity; as a result frequently failing to capture the real food exposure (49,57).

The analysis of broad categories, such as supermarkets, without an independent analysis of outlet sub-types such as discount supermarkets, can

miss the opportunity to find real associations. Drewnowski et al. found no impact on obesity, but after analysis by subtype, adjusting by socioeconomic status and individual variables were all implemented, they obtained an inverse association between the type/category of supermarket and obesity (82).

4.6 – Chapter summary

This review has revised all relevant literature related to the association between community food environments and obesity in the U.K., as well as the US, Canada and Australia. Until now only a few reviews included the relationship of the community food environment and obesity and no reviewed publication had previously explored these selected countries (40,49–52). The analysis of the studies was developed by systematically reviewing the literature drawing on the methodology developed by Cobb et al. in their systematic review (2015) on the relationship between local food environment and obesity in USA and Canada (49).

Initially New Zealand and Ireland were included in the sample but no studies were found which met the inclusion criteria.

The comparison of the studies provided a lens on the nature of the association between community food environments and obesity. The chosen studies also identified the most frequently used food sources and GIS measures in order: a) to assess the communities' exposure to different food types and b) to distinguish which food outlets were used as healthy and less healthy proxies for food availability.

4.6.1 Findings in relation to studies' methodologies

Neighbourhoods have a great diversity of food sources; however, most of the studies measured only a few types and rarely combined them to increase the exposure of the community food environment. This finding allow me proving my first hypothesis, which set out that foodscapes, include a limited type of food sources to represent the community food environment. There is a need to capture a wider range of food outlets to expand an understanding of the

community food environment and analyse their influence in dietary patterns and health outcomes. In terms of healthier food exposure, there is a need to expand the exposure, by including more outlets offering healthier ingredients. Such outlets could include: i) organic food stores, ii) delicatessens and iii) produce vendors in order to explore their presence and potential impact on food purchase at individual and group level. Additionally, it is necessary to validate the data directly in the fieldwork together with the application of a more accurate classification system (5,49,112). Such a system would include food sources types and sub-types in order to improve the exploration of food deserts, as well as the description of a healthier food environment in a neighbourhood. Regarding less healthy exposure, similar to the previous case, limitations in the inclusion of only a few types of food sources, together with the misclassification of the types and sub-types can decrease the chances of accurately identifying the real community food environment exposure and potential obesogenic food sources (49,50,57,112). In terms of my research design, the inclusion and pertinent classification (considering the UK context) of a wider range of less healthy food source types and sub-types improves the exploration and description of the obesogenic community food environment in any given neighbourhood (113).

The definition and selection of the concept: ‘neighbourhood’, including the use of a buffer zone extension, is also relevant to capture the residents’ spatial exposure. The use of administrative boundaries, such as census tracks or blocks, could not wholly represent food outlets’ locations or the socio-economic variables influencing and informing the populations living in those neighbourhoods (49,50,52,112). The lack of a buffer area to explore the food sources around the neighbourhoods can also decrease the food sources exposure measurement for the people living in peripheral residential areas, thereby negatively affecting the true findings. It is necessary to identify the most natural neighbourhood boundaries that represent the residents’ authentic shopping area(s)(5,40,49,112).

Proximity was measured in almost all the studies by employing the concept of 'walkable distance'. The one exception to this option was a study that assessed 'direct distance' to the nearest road (75). This model is not recommended as it bears little relationship to the distance a subject is obliged to walk in order to buy food. To determine a reasonable perimeter to assess GIS measures is essential so as to obtain the real exposure. None of the studies assessed all the measures together. This finding is relevant due to means that the obesogenicity assessment has been incomplete in many studies. It also allowes me to prove my second hypothesis, which states that foodscapes' spatial analysis do not combine accessibility measures to analyse the neighbourhood obesogenicity. The calculation of the mentioned spatial measures, in combination with the assessment of quality via the food environment index, could offer the most complete evaluation of a community food environment. Such a model covers all the variables of this sub-type of environment: a) number, b) type and c) location, and can be strengthened by the addition of the ratio of healthy to less-healthy food exposure.

Finally, the analysis of categories by type and sub-type increases the chance to identify valid associations between community food environment variables and obesity (112,113). The narrowing focus is an essential step, since broader categories might be masking the effect of specific types of outlets.

4.6.2 Findings in relation to the study's themes

Though studies reported mixed results and had several flaws, 75.6% of the studies analysed in this review showed that there is an association between a community food environment and the obesity levels of residents living in those communities. The research locations were the US, Canada, Australia and the UK and the cited researchers found at least one positive or negative association. Considering most of the sample has a cross-sectional design, it is only possible to confirm that the community food environment exerts an influence over the residents' levels of obesity; however, causality cannot be confirmed. Confirmation of such a causal relationship is essential to better understand that the impact of community food environments on the

obesogenic process it is not an isolated problem in one region; it is a dynamic scenario developing simultaneously in different parts of the world. Cobb et al. and other reviewers have explored similar associations and also obtained mixed findings (40,49–52). Regarding the UK studies, the few included investigations reported null findings, and only one suggested that obesogenic community food environments are also present in the country (90).

As described by others reviews, the studies reported positive, negative and null associations. In the case of positive relationships, the community food environment was associated with an obesogenic process, where higher exposure to less healthy food sources (food swamps) was linked to higher obesity rates and the likelihood of developing obesity in all age groups and all four cited countries. Negative or inverse associations were related to two realities: i) a protective healthier food exposure decreases the risk and rates of obesity and ii) lower levels of healthy exposure greatly increases the odds and rates of developing obesity. Only 5 studies found associations confirming both realities can co-exist and according to different authors, strengthen the obesogenicity of the environment. Despite the studies being conducted in the US, the findings confirming food swamps and food deserts separately in the UK might provide evidence that both contextual variables can co-exist, if the study is designed to measure them.

The combination of both realities, ‘food deserts’ and ‘food swamps’, could be a powerful promoter of obesity in the UK, thereby creating a strong obesogenic residential trap. Even in absence of food deserts, and having a reasonable exposure to healthier food sources, the attractiveness of fast-food, convenience stores, and other types of local food sources constitute really tempting takeaways (48). They can, by themselves, promote a higher consumption of ready-to-buy and serve, abundant portions of tasty high-in-fat and high-in-carbohydrates processed products. Although obesogenic community food environments do not explain the obesity pandemic, they may strongly contribute to the increasing obesity rates across all age groups, as

such sources are more focused on economically disadvantaged urban inhabitants (8).

Each research adjusted for, and took account of, low-income variables (income and/or SES) at individual and neighbourhood level in their models and statistical analysis. This adjustment was fundamental due to some research having confirmed previously that poor urban settings are where obesogenic environments are strongly developed. Approximately 21% of the publications reported that odds and rates of obesity were higher in deprived neighbourhoods. As other reviews discussed and other authors concluded, higher rates of obesity may suggest that impoverished environments have a stronger influence on obesity promotion than do more affluent contexts. Such a prognosis applies particularly to the most economically disadvantaged residents who have other factors that could increase the individual risk and likelihood of developing obesity. Among such factors are: i) low education levels, ii) barriers to move faster or take short-cuts within the surroundings to buy food, and iii) lack of places and opportunities to do physical activity. As I already pointed out in the previous chapter, the negative influence of the environment over individual risk factors is well known as the 'deprivation amplification' effect. This issue could play an important role in the community food environment's influence over: a) food purchasing, b) dietary patterns and consequently c) the nutritional status.

Nine investigations found predominately non-significant associations in the U.S., Canada and the UK, using children and adults populations. Cobb et al. (49) and other review authors have discussed null results and concluded they cannot be discarded: a) is there the possibility that there is truly no relationship and b) nor is there a real association; a serious research dilemma. Authors in the field of concern being addressed in this study have confirmed several limitations that may affect statistical analysis, weakening the force of association or producing null associations (40,49). Among the most reported limitations are participants' selection; a point which can affect the representativeness of the research sample. The use of self-reported BMI

measures and a smaller sample size (underestimating the magnitude of the outcome) are also factors that should be taken into consideration. As mentioned above, other errors may affect the exposure magnitude of the outcome. The most common examples of these research errors are: a) the selection of a few food outlets types (partial capture of the exposure); b) the use of a smaller food outlet sample size (underestimate the magnitude of the exposure); c) food business datasets validation (incomplete or outdated data decrease the sample); d) misclassification of food sources (affecting the healthy and less healthy magnitude of the exposure); e) neighbourhood definition and f) neighbourhood selection (capture real exposure). Flaws in the analysis also appeared in the studies, as GIS measure selection, when researchers used individual measures, instead of combining two or three. Another flaw was the analysis of broad categories, thereby excluding sub-types which negatively affected the analysis and inhibited the identification of true associations. Considering these issues, it is feasible to suggest they may have interfered in attempts to find any valid (true) associations. Although all the studies included in the sample presented similar flaws, it is not possible to dismiss the possibility that in some of these cases it could have been challenging to associate outlet-based measures with the residents' obesity levels (91).

This scoping review has identified and presented limitations that should be considered in this summary. In term of methods, this review restricted the samples to only six countries; a total reduced to four when Ireland and New Zealand failed to yield any publications for review inclusion. This reduction to four nations helped to miss investigations that may have contributed to the analysis of the association between community food environments and obesity. Furthermore, excluded studies evaluating overweight and BMI changes as outcomes, as well as those using activity-space methods, could have enriched the discussion; weight gain is a continuum process that reaches beyond the context of community food environments. Additionally, this review did not appraise the studies' quality. However, 78.3% of the sample was

selected from the review carried out by Cobb et al. who did evaluate all their studies. According the authors, the whole sample was informed by sub-optimal flaws, as noted above; as a result, there were no differences in the findings between studies with one or more flaws.

4.7 – Justification for this research

Findings from the literature analysis provide a framework which establishing a process of mapping the community food environment in a Glaswegian neighbourhood and the identification of some key contributors towards obesogenic environments. The following information gaps were detected and included in the study aims.

1. The literature showed a **lack of data** about the deprived community food environments' main features. There are only minimal descriptions of the presence and location of different types of food sources that are interacting with residents in poor living conditions, such as food banks or entertainment related outlets, and how access can influence this interaction.

2. Food deserts and food swamps are part of the obesogenic community food environments. Although **food deserts** have been confirmed in Glasgow and other parts of the U.K., the data about the deserts' distribution patterns is still limited. That information failed to incorporate all the healthier food sources, which limited the description of those locations. **Food swamps** were also confirmed in different parts of the U.K., including Glasgow; however, as well as food deserts, their measurement does not incorporate all the food sources, thereby limiting the description and knowledge about them.

3. Only four studies investigated **simultaneously** food deserts and food swamps and **none of them** was conducted in Scotland.

Therefore, new research is needed at neighbourhood level to: a) better describe the unique characteristics of a deprived community food environment,

b) confirm the presence of food deserts and food swamps in the country and c) describe in better detail food deserts and food swamps obesogenic characteristics and synergy if they are coexisting in the same food environment.

The study results may be generalised and be used as new evidence for Scotland to help policy makers, local authorities, the third sector, NGOs and civil society to design and implement new local policies. Although the study is focused on a particular neighbourhood with unique characteristics, there are common factors that presumably would be present in deprived neighbourhoods that will allow policy makers to extrapolate this neighbourhood food environments features to settings with similar contexts. This contribution is coming at a relevant moment for the country, where obesity rates are higher than ever and when the government is initiating new strategies to tackle the problem. The study will also add contemporary evidence to the literature on the topic, which could be of particular value to researchers interested on relationships between community food environments and obesity.

Part of the knowledge gap lies in the methodological challenges presented to researchers carrying out this type of investigation.

4. The scoping review identified the **methodological gaps to shape neighbourhoods and capture, classify and analyse the community food environment exposure**. These limitations are highly relevant if one wishes to explore all the present elements in community food environments, as well as determining how accessibility is influencing food availability within deprived residential zones.

Findings from the scoping review have shown that it is necessary:

a) to improve the definition of the study area, using representative neighbourhood limits and a buffer zone, to capture in a better way the residents' food shopping area;

b) to include in the design, all the present food sources types in order to visualise the complete community food environment and detect healthier exposures, food deserts and food swamps within the neighbourhood;

c) to apply an accurate classification system to improve the description and analysis of the exposure;

and,

d) to identify the combination of different GIS measures which are needed to effectively explore spatial accessibility and distribution patterns within the community food environment.

Chapter 5 – Methodology

This chapter describes the design and methodology used in the research to achieve the study's aims. The objectives of this chapter are:

- to describe the research design
- to portray the research setting
- to depict the selected methods
- to describe the ethical approval

It is divided into five sections:

section 1 provides a description of the design and its components;

section 2 depicts the research setting I selected as a representation of an economically poor urban environment;

section 3 outlines the data sources and methods I used developed to assess the foodscape;

section 4 sets out the sensitivity analysis of the main data source;

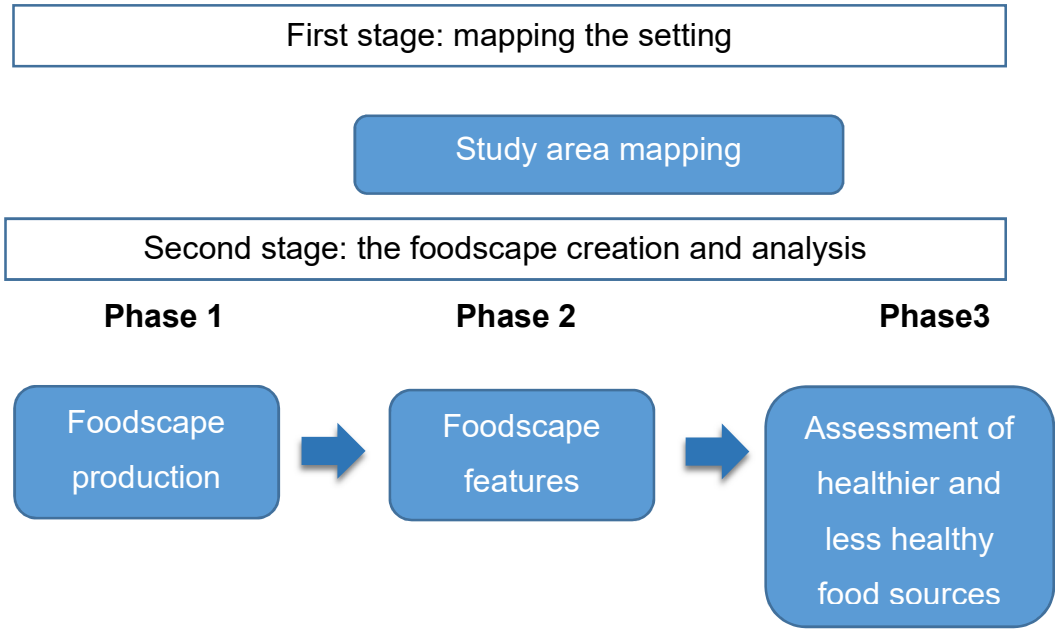
section 5, outlines the ethical processes adapted in order to ensure that the whole research journey was carried out in an ethical way.

5.1 – Study Design

The study has a cross-sectional design. This design focuses on the measurement of food exposure at a single point in time as shown in Table 5. This type of observational design is characterised by measuring both outcome (obesity) and exposure (community food environment) at the same time and in one single moment (13). It was hoped to also measure the relationship between the community food environment and the residents' obesity; however, this option was not feasible due the lack of a BMI dataset for the Whitewood residents. The lack of local obesity-prevalence data offered an excellent

opportunity to focus on the exploration of the community food environment's features

Figure 5. Cross-sectional design scheme



The unit of analysis is a food source; therefore, in accordance with the inclusion criteria, the sample is composed of all the physical food sources within the foodscape. In comparable research, food outlets are usually used to represent all the places where the residents, or people transiting through the area, can purchase food (2). Having analysed the scoping review findings, the definition of **"food sources"** was extended to also incorporate: a) the informal food market and non-traditional food sources (2). The most common types of these additional categories are street vendors and charitable organisations. Furthermore, food sources also include the act of obtaining food, including free food through community centres and the distribution centres for food for social benefit such as food banks and 'soup kitchens'. The incorporation of these type of food sources reflects the particular economic and social climate impacting Scotland, and in particular this poorer region of Glasgow city (16,42).

The exclusion criteria are all the food sources where essential data, such as address, coordinates and/or classifications were unobtainable and where food sources were not physically present in the study area. Specifically, this latter category related to: a) special food deliveries or b) restaurants located in other neighbourhoods but selling food ordered via phone or internet to the study

area. Also excluded were: i) outlets not selling food even if they were registered as previously having been a food premise, ii) outlets not open to the public and iii) food sources not found in the validation process.

The setting for the study is the Whitewood neighbourhood of Glasgow, Scotland and parts of the surrounding neighbourhoods. The neighbourhood has all the characteristics of an obesogenic community food environment: a) high obesity rates, b) high food business concentration and c) high levels of socio-economic deprivation. The next section explains Whitewood's features and the neighbourhood selection process.

A two-stage design was adopted, as seen in Figure 5. In the first stage, I identified the area, developed the data collection tools appropriate for the complex nature of the area, built the food sources' database using direct and online validation, as well as through GIS to produce the foodscape basemap. The second stage of the research design is divided into the second and third phases, which was where I developed the data analysis tools and carried out the analysis. During the second phase, I explored the foodscape features of the area; employing, and then analysing, three discreet measures: i) **the predominance, ii) the proximity** and iii) **the concentration** of food sources to residential areas. In the final third phase, once data was collected, I re-categorised the food sources into two specific categories: i) healthier and ii) less healthy food sources. I compared these sources in terms of predominance, proximity and concentration within the study area.

Based on the scoping review, I included in my research design a wide range of methods and approaches with which to explore the community food environment in a deprived urban micro-area. The key elements integral to the quality of this research, and which provided the unique contribution of the study are: i) the study area size, ii) the data collection methodology, iii) the data classification and iv) the combination of study variables. The focus of previous studies has been on the coverage of larger areas to increase the data gathering exposure area. However, to investigate in-depth a small socially defined neighbourhood provided me with the opportunity to explore a local

urban environment in more detail. As has been suggested by Lake et al. and other researchers, it is essential to carry out new research by conducting studies which incorporate meticulous/exhaustive data collection in order to create more complete foodscape mapping and ultimately maps (5,49,112–114). Therefore, I combined a range of different methods and sources in order to audit the community food environment and build an updated and more complete database than had previously existed. I also categorised the food sources, using a classification specifically designed to identify a wide range of traditional and non-traditional food establishments' categories, which are commonly present in the community food environment. This classification is particularly sensitive to detecting "food swamps" or unhealthy community food environments (113). In terms of the variables, I incorporated key features from a spatial perspective. The calculation of prevalence, proximity and density allowed me to assess frequency, distribution and concentration of the sample. Most important, the configuration of the data into the two categories: i) healthier and ii) less healthy food sources allowed me to explore the research population's potential obesogenic exposure by considering the available human, economic and time resources.

The research design has facilitated taking a unique "snapshot" of the community food environment. Through the creation of a food map and the spatial analysis of the neighbourhood's exposure to a range of food sources, I sought to assess the foodscape's obesogenicity. Exposure to food sources, meaning in this case: *'the way in which environmental and biological factors interact with a person or group of people',* has an impact on both the health and nutritional status of consumers (13). The exposure to community food environments and their elements, such as less healthy food sources has been identified as a significant risk factor source for many diseases, including obesity (8,13). In this case, food sources are being considered as environmental factors that have the potential to produce negative or positive impacts on residents' and workers´ food shopping behaviour and dietary patterns that will affect or protect their nutritional status (7,13).

To improve the communication methodology and critical evaluation, I followed the Geographic Information Systems Food Environment Reporting (GEO-Fern) guidelines and checklist proposed by Wilkins et al. (112). The guidelines have five dimensions: i) the choice of food outlets' datasets, ii) the methods used to extract the food sources, iii) the approach to define the food outlets' constructs, iv) the geo-coding methods used and v) the operationalisation of food sources access (3). Each dimension has been comprehensively considered in every stage and is discussed and explained in more detail in the following sections and sub-sections of the present chapter. The Geo-Fern checklist is displayed in Appendix 3.(112)

5.2 – The setting: neighbourhood selection

I chose to examine the drivers of an obesogenic neighbourhood in a deprived urban area. To observe a micro-area permits a researcher to focus in more detail on the community food environment. Such a focus will include the identification of all the types of food sources, including food deserts, food swamps and those outlets related to the deprivation level. This assessment is not possible in studies measuring community food environments at a greater or macro scale (county level); nor can multiple neighbourhoods be compared, due to the data collection capacity of a micro-focus study being relatively limited. After analysing a number of different deprived urban settings across Scotland, I chose to examine a low-income neighbourhood in Glasgow. I consulted different experts to identify the most suitable research setting within Glasgow. I attended Individual meetings with the team leader of the Environmental Health Department at Glasgow City Council; the Diet, Nutrition and Health WG Chair, at Glasgow City Council; an information analyst (NHSGGC), the Research & Evaluation team leader (NHSGGC) and the Senior Public Health Analyst in the Public Health & Corporate Information team at NHSGGC. All of these expert sources agreed I should explore the East area of the City, as those neighbourhoods had poor community food environments that could be considered as obesogenic. It was also identified as a good opportunity to contribute additional data to the City's council especially as they

had been implementing different improvements in these suburbs. Previous research in the area was conducted 5 to 10 years ago, thus there was a need to update area data (24,76,103,115).

I examined the following neighbourhoods: a) Shettleston, b) Whitewood and c) Dalmarnock. Shettleston had been the setting of a recent investigation conducted by the council and Dalmarnock had less commercial life than Whitewood. Therefore, following suggestions from the experts, and after a preliminary visit to the neighbourhoods to confirm the study's feasibility, including safety issues, I decided to conduct the research in Whitewood. This decision was authorised and supported by my supervisors. The setting selection criteria involved different features, with three of particular importance: i) high levels of socio-economic deprivation (residents with high levels of poverty and unemployment), ii) high levels of commercial activity and iii) high levels of obesity. Other relevant characteristics included: a) high population density, b) a poor health profile, c) low levels of higher education, and d) easy accessibility by foot from the central traffic system. The reason to start looking for a highly deprived area, as it was described in the scoping review, is that obesogenic environments are more prevalent in those deprived areas. Further, high prevalence of obesity among the residents indicates the likelihood of an obesogenic community food environment existing within the neighbourhood. High levels of commercial activity are also expected due to the focus of this research being an analysis of the residents' exposure to food outlets.

The setting

Whitewood is an emblematic area of Glasgow, which played an important role in the Scottish industrial revolution; it has a long history of deprivation (116). The neighbourhood belongs to the urban areas that have been determined to be informed by the "Glasgow effect"(116). Whitewood possesses all the features of a low-income and obesogenic neighbourhood: i) high levels of deprivation and poverty, ii) high proportion of social rented housing, iii) high proportions of the population economically inactive and unemployed, iv) high proportions of the population without higher education, v) high numbers of

people who are overweight and obese, with poor dietary patterns (117–119). The neighbourhood has a scenario of economic deprivation considerably higher than the city average (117,119). In 2011, income deprivation rose to 37.9% in the neighbourhood, almost doubling the 21% of Glasgow overall (SMID 2016) (117,118). A similar case can be with an examination of the Glasgow's economically inactive population. In the city, the average was 30% in 2016, whereas in Whitewood the level was 45.21% (117,118). In terms of social rented housing, Glasgow's overall figure in 2016 was 35.1%, versus 70.2% in the Whitewood neighbourhood, in 2016 (119) The unemployment rate in the city was 5.7%, whereas in 2014 the level in the neighbourhood was 14.89%. Regarding the education level, in Glasgow 42.4% of its residents had a higher level of education, compared with 26.1% in Whitewood (117–119).

From an ethnic viewpoint, 93.68% of the residents are white, having a very small representation (6.32%) from other groups (120). Regarding the health profile of Whitewood's residents, over one-third of the population are disabled (120). According to the 2014/2015 Health and Wellbeing Survey (HWS): a) 46% of the inhabitants are smokers, b) 9% exceeded the weekly limit for alcohol consumption and c) 12% admitted being drunk the previous week (120). In relation to the physical activity patterns, 53% of the residents have accomplished the target of 150 minutes or more of moderate physical activity per week and 54% walk, bike and use public transport to travel to work or their study place. In terms of diet, only 21% reported they had met the target of 5+ portions of fruit/vegetables per day and 15% affirmed they consume no fruit/vegetables per day (120). About the nutritional status, 22% of the participants recognised they are obese, however, these figures might be considerable higher due to participants self- reported their BMI (120). These measures might be underestimated or be hidden by shame or stigma that surrounds obesity. Considering all these characteristics, this neighbourhood meets all the criteria to be selected as the research setting, which findings will be a valuable information for local authorities.

5.3 – The Methodology

I divided the research into two stages. Table 3 shows the procedures associated with each of the two stages can be seen.

Table 3. Flowchart of the main procedures in the study implementation

Stages	Sub stages	Procedures
Stage 1: the setting	Study area mapping	• Software selection • Neighbourhood boundaries selection • Buffer selection criteria • Foodscape basemap creation
Stage 2: the foodscape creation and analysis	Foodscape production	• Postcodes map extraction • Food sources data collection • Foodscape database set up • Food sources categorisation • Fieldwork validation • Online validation • Foodscape database completion • Food sources geocoding
	Foodscape features description	• Predominance calculations • Proximity calculations • Density calculations
	Assessment of healthier and less healthy food sources assessment	• Healthy and less healthy food sources re-categorisation • Predominance calculations • Proximity calculations • Density calculations

Stage 1: mapping the setting

5.3.1 Study area mapping

5.3.1.1 Software selection

I installed Quantum GIS (QGIS) software, version 2.18, in order to produce a mapping of the foodscape. QGIS is a free and open source geographic information system (GIS) that enables the user to view, edit and analyse the foodscape geospatial data (121). QGIS is an excellent alternative to ArcGIS software, due to the former's license being free. QGIS is well developed, user-friendly and, in this version, has a multiple visualisation tool to highlight points of interest.

5.3.1.2 Neighbourhood boundaries selection

Geo-Fern guidelines emphasise there is no consensus in zoning methods (112). According to the guidelines, it is crucial to provide the rationale for the choice of zone type and size, to avoid what has been described as the "uncertain geographic context problem" (112). This problem happens when the chosen area is unlikely to represent the true extent of an environment with which a person interacts (112,122). Considering their recommendations and the scoping review findings, in order to map the foodscape in Whitewood, different geographical alternatives were evaluated to shape and define the neighbourhood (112,122). To take this decision, I reviewed different Glasgow Council websites to locate the existing official boundaries. After the search, I found five different available options of the boundary shape of Whitewood: i) Glasgow electoral wards, ii) housing administrative boundaries, iii) datazones, iv) postcode zones and v) the community council boundaries (123).

I conducted a consensus meeting with an advisory group of experts including an NHSGGC information analyst, the HWS managers and a geographer familiar with Glasgow spatial analysis, for the purpose of assessing the advantages and limitations of each of the five different boundaries. The rationale for my final choice of boundary is presented below.

I discarded ‘housing boundaries’ as they joined the Dalmarnock neighbourhood to Whitewood. I dismissed the datazones and postcodes' delineations due to the fact that they included residential areas belonging to the surrounding neighbourhoods, such as Braidfauld and Barrowfield. In the case of the electoral wards, I discarded them because they divided Whitewood in two: wards 9 and 19, as well as including areas from the surrounding neighbourhoods.

After overlapping the available maps, the community council boundaries were the only arbitrary limits that were compatible with the consensual borders of the neighbourhood (124). These edges included historical points of interests, residential areas and traditional and emblematic streets. Examples include: i) the Forge Complex, ii) the cemetery, iii) the Emirates Sports Arena and streets such as iv) Gallowgate, v) Springfield Road and vi) London Road, which are all located in Whitewood’s neuralgic centre, near the Celtic Park Stadium. Administrative limits try to incorporate natural communities and, as far as possible, have a regular shape and contain households with similar social characteristics (112,122). Community councils were created as civil committees in 1973 by the local authority (Glasgow City Council) (124). They participate as voluntary bodies to support the Glasgow City Council to co-ordinate and express the wider views of the entire community within that community’s agreed boundaries. Hence, they are included in the consultation process for all planning applications, including the neighbourhood boundaries (124). The participation of the community in the boundaries’ definition shaped the neighbourhood, as the residents perceive it; an input which increases the possibility of representing a more consensual local food shopping area (124). Though these limits are more natural, one limitation was that the Celtic Park Stadium was not formally identified as part of the neighbourhood, even though it was seen as very much a commonly accepted part of it.

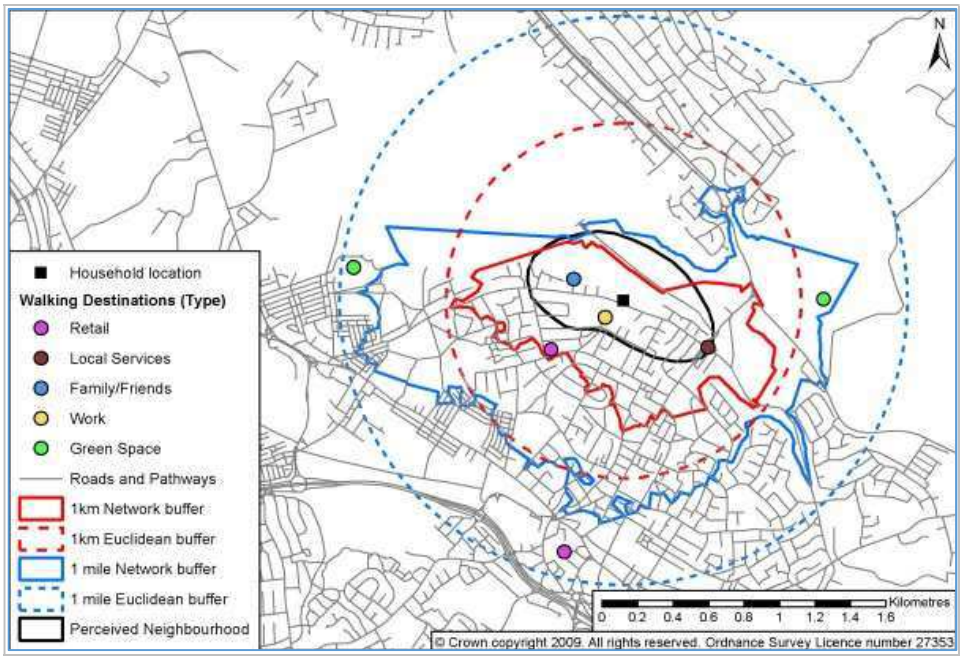
I obtained the neighbourhood boundaries layer from the Scottish Government spatial hub website (123,124). This is a spatial open data storage source,

managed by the Public Health & Corporate Information Team. I downloaded the layer in a shape file updated in August 10th 2018.

5.3.1.3 Buffer selection criteria

To fix the area limitation mentioned above, and to ensure the food sources near the neighbourhood boundaries were included, I drew a second border to encompass a walkable area beyond Whitewood. This measure is defined as a buffer and is used to establish a perimeter around the selected zone at a specified distance (112,125). Adding a buffer area improved the coverage of the community food environment because it expanded the imposed edge into a larger shopping zone (112,125). The best buffer size is considered to be a Euclidian distance of 1600 meters (m) which is approximately a 20 minute walk (125). This cut-off distance point has been one of the most frequently applied in other studies (104,125,126).

Figure 6. Whitewood neighbourhood and the buffer boundaries



Source: What is my walking neighbourhood? A pilot study of English adults' definitions of their local walking neighbourhood (22).

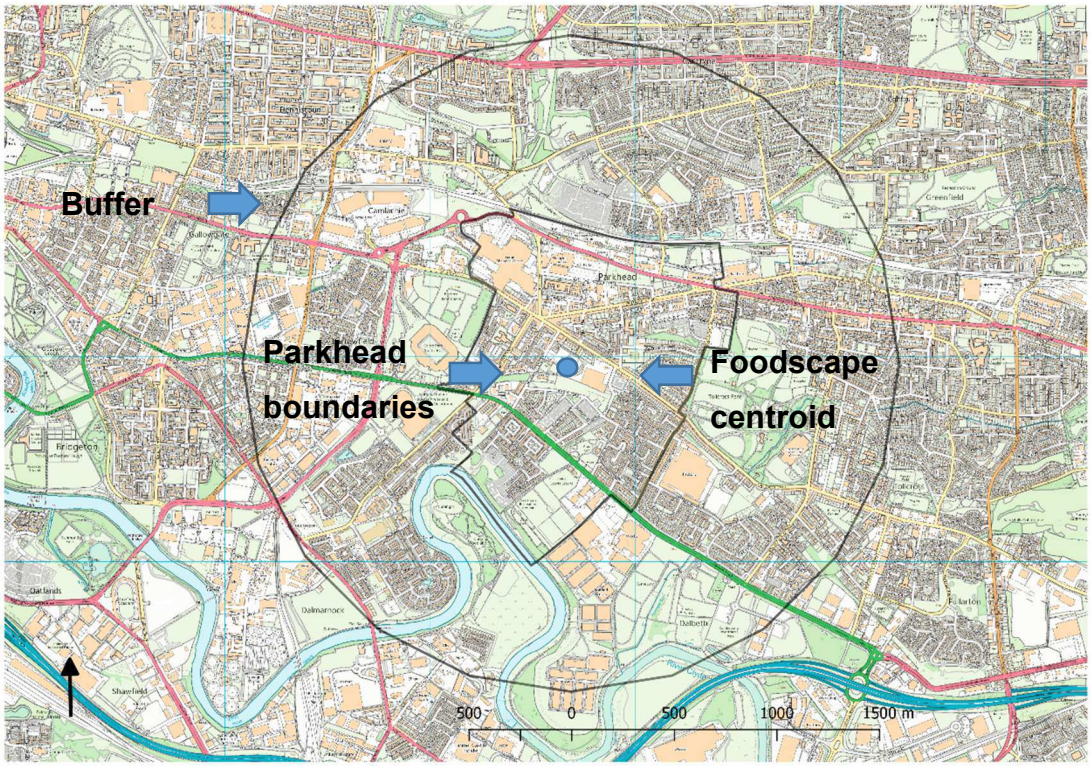
A study conducted in the UK has shown that more than 95% of usual walking destinations to food shopping are made within that 1600 m distance from the households (125). The area within this perimeter is known as the buffer zone,

and the food sources within it will be called buffer food sources (113,125). Considering this reason, (as shown in Figure 6), I chose to draw a 1-mile Euclidian buffer following the described example.

5.3.1.4 Foodscape basemap

After selecting the foodscape boundaries and choosing the buffer, I prepared a database for the base map. I first created a base map of Glasgow and Whitewood, using a package of open source maps (digital layers) from the UK Ordnance Survey (OS) Open Data™ products in July and August 2018 (127). The map data were available in ESRI® shapefiles through Digimap Collection, using the University of Edinburgh license. I selected the North East area of Glasgow, where the neighbourhood is located. Once all the data layers were downloaded, crosschecked and labelled, I created the base map by merging them via QGIS. I combined 12 files to create the Glasgow base map layer, adjusted to the British Coordinate Reference System (CRS). After that, I added the Whitewood neighbourhood layer, as well as creating the foodscape centroid and the 1- mile Euclidian buffer area. All the layers downloaded to build the base map and the procedures I followed in QGIS are described in Appendix 4.

Figure 7. Foodscape base map



As is shown in Figure 7, the foodscape base map contained all the basic geographical elements to later geocode the food sources and calculate the spatial measurements within the study area. The base map includes local details of the different Glaswegian neighbourhoods within and around the buffer. The map encompasses roads, railways, vegetation, boundaries, buildings and contours. I enriched the map adding the OS MasterMap Greenspace layers for the selected area (127). This improved the visualisation of the Celtic Park Stadium, the Tollcross Park and the Emirates Sport Arena, which are relevant points of interest in the map. Using the QGIS measuring tools, I calculated the foodscape area (7.911 km²), the neighbourhood area (1.556 km²) and by subtraction, the buffer area (6.355 km²).

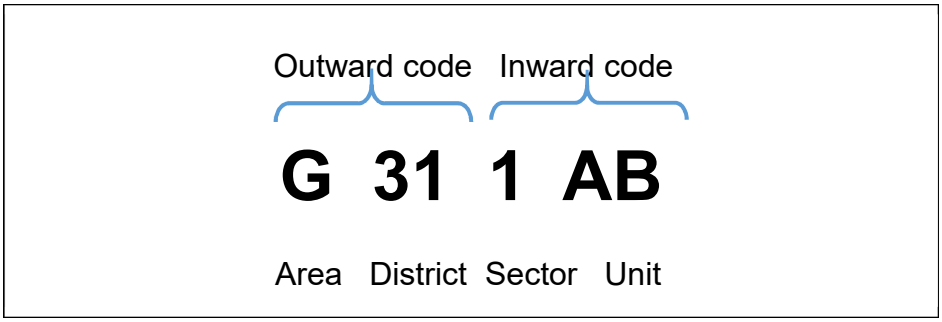
Stage 2: foodscape analysis

5.3.2 The foodscape production

5.3.2.1 Food sources postcodes map extraction

To identify the food sources' addresses, I first searched all postcodes associated with the study area. A postcode is a combination of six characters composed by letters and numbers, which defines four different levels of a geographic unit (128). As it can be seen in Figure 8, every postcode is divided in two parts: the outward code and the inward code. The outward code contains the postcode area and district. In the case of Glasgow the area starts always with the letter "G" and for Whitewood, the district number was 31. Hence, outward code for Whitewood was G31. The inward code is used to identify the local area and contains one number followed by two letters. For each postcode group an address was set with its corresponding coordinates.

Figure 8. Postcode composition



Postcode identification allowed me to identify and extract the foodscape addresses from Glasgow City food premises and businesses directories. The postcodes allowed me to restrict the areas I needed to search in order to proceed with the later data extraction (128). After the extraction achieved via QGIS software, I found 591 postcodes in the buffer and 196 in the neighbourhood. The extracted datasets included the postcode in consecutive order and their respective coordinates among other geographic information. The final list of postcodes included the districts G31, G32, G33, G40 and G73

and 787 full postcodes. The procedures I followed in QGIS to extract the postcodes are described in Appendix 5.

5.3.2.2 Food sources data collection

There is no unique database where all food sources are named and described. Therefore, I combined two different methods: a) intermediate and b) direct in order to identify and classify the types of food sources (112,113). Intermediate methods use secondary data sources such as: i) telephone directories, ii) business directories and iii) government listings to find the food outlets (112,113). The direct method which, in previous studies, has been referred as "ground truthing" or field validation, uses the "audit in person" within the study area to confirm and search the food sources (112,113). I searched three digital directories, different websites and conducted a field and online validation to identify and collect the food source data. This combination increased the reliability, completeness, and validity of the data. I included all the identified food sources in an Excel file under the name of *foodscape database*. The collection process started in April 2018 and finished in October 2019. The six revised directories and websites that I used were: i) Glasgow City Council food premises list, ii) the alcohol premises list, iii) online yellow pages, iv) the Trussell Trust, v) the independent food aid network (IFAN) websites and vi) Google (129–132).

As it has been suggested in the Geo-Fern guidelines, I describe as follows the most relevant information of the food sources data lists and websites (112).

The Glasgow City Council food premises database

Food premises are defined by FSS as "any unit of food business" and this is legally described as "any undertaking whether for profit or not and whether public or private, carrying out any of the activities related to any stage of production, processing and distribution of food" (133). I requested the latest version of the food-licensed premises list of Glasgow City in 2018. I chose this database as it is the official directory of food licenses in the city. At the national level, most types of food business are required to be registered with the

Environmental Health Department at least 28 days before they plan to open (133). The directory contained all the registered food business in the city and was built mainly for licensing, inspection and planning purposes. After registration, Environmental Health Protection Officers are required to inspect the business on a regular basis. Lake et al. found that Newcastle Council food premises' list achieved a high sensitivity (83.6%) versus the fieldwork (113).

I formally requested the data through the Environmental Health Department. The Chief Department Officer provided me the list via email in an Excel file. He confirmed the dataset was collected during the second semester of 2017 and published by the end of 2018. It comprised food premises names, location, full address, the wards to which they belong and their food business classification with their respective codes. I also received a separated appendix with the list of codes to complete and understand the categories. The classification included "peripheral categories", which are outlet categories where the main products to sell are not food. Nevertheless, they can provide food, from a simple snack or confectionary to more elaborate offerings (113). Examples of these categories include businesses such as pharmacies, department stores and pubs (113). The classification employed by the council corresponded to the Food Hygiene and Food Standards categories of establishments proposed by the Food Standards Scotland (FSS). The FSS is the public sector food body for Scotland. The organisation is responsible for providing advice and policies for consumer protection (133). This data allowed me to compare the classification of food sources against the official categorisation, creating a strategy for triangulation. The FSS classification is shown in Appendix 6.

I received a list of the food-licensed premises from the Environmental Health Department of Glasgow City in January 2018. The Excel file contained 5.936 premises which covered the whole Glasgow City. Included in the list were: i) an internal reference code for the premises, ii) the commercial names, iii) location, iv) food premises classification and the electoral wards in which those premises were located. The location included the full address (street name, street number and postcode) and the classification included a code for the

category and/or subcategory of the business. I conducted the search of the foodscape postcodes, using the digital file and a printed copy just to crosscheck I had not missed any postcodes. This process consisted of searching and finding specific postcodes; I scrolled through all the databases to identify first the outward codes, followed by the inward codes. I then compared in parallel the printed postcode list to ensure I was not missing any postcode. One by one, I identified and extracted the food premises data no matter what was their classification. I saved a new Excel file under the name of “Foodscape database”. Finally, I entered 272 food premises records into the new database. As the Geo-Fern checklist suggests, I set out to include a missing data analysis (112). However, in this case, all the records were complete in both the neighbourhood and the buffer area.

The Glasgow City Council alcohol premises database

To ensure I was able to identify all the food related data in the area, I requested the alcohol premises dataset for the city. Food premises do not necessarily include all the establishments offering alcohol (which also sell snacks as a secondary business). The list contains all the registered alcohol businesses in Glasgow. As well as the food premises list, the ‘alcohol directory’ was built mainly for licensing, inspection and planning purposes. As with the previous dataset, the data was collected during the second semester of 2017. With regard to the publication or release date, I could not obtain that information from Glasgow Council.

In this case the officer in charge of the dataset, requested me to forward a shape file with the foodscape area. The reason was that the Department of Environmental Health could not authorise the release of the whole list; however, they could deliver prescribed sets of data within the area I defined. I received the foodscape alcohol premises list in May 2018. The file contained 81 premises, with information including the commercial name and location of the businesses. The latter included the full address: street name, street number and postcode. I cross-checked the data with the food premises list and I found 18 new records, which were copied into the foodscape database. The

rest of the premises were repetitions and/or located outside the foodscape. As the Geo-Fern checklist suggests, I included the missing data analysis. I found one record within the street number and to find it, I searched on Google the name of the establishment, which I added to complete the record.

Online Yellow Pages website

I reviewed the Yellow Pages business directory via the internet (129) to complement the search of the official Glasgow Council's lists. Yellow Pages is the biggest private business directory in the UK. Despite this, the data source achieved only a moderate sensitivity (50.9%). It is a free and fast access data source, commonly used by local customers and always cited in community food environments studies (113,134,135). It is organised by business category and advertisements require payment. Its online version is updated annually by the company, alongside customers' reviews (129).

The data was published in January 2018 and accessed in May and June of the same year. The website gave me the possibility to save a small amount of data after sign-in. I identified eleven categories and eighty-one sub-categories related to food and beverages, including peripheral classifications. The 11 categories are: 1) restaurants, 2) pubs, 3) café & coffee shops, 4) takeaway food, 5) bakeries, 6) grocers & convenience stores, 7) supermarkets, 8) delicatessens, 9) function rooms and banqueting, 10) entertainment venues and 11) others.

To find potential missing food premises, I created a search strategy based on the webpage business directory. Firstly, I revised all the food and beverages categories available on the internet site "yell".com, starting with a search via the words "food" and "beverages", after which I incorporated all the related terms that appeared on the search. I also added the food source categories suggested by Lake et al. as search terms. I included peripheral categories to expand the search and capture hidden food sources.

After building a list with eleven food categories based on the classification from Lake et al. I obtained a total of 125 search terms. Then, I introduced every word in the search box and the location in a second box. I crosschecked every food business that was identified in the study area. I took into consideration that a business can be listed under multiple classification categories and this overlapping can generate duplicates and an overestimation of results; an issue addressed by Wang et al. and Lake et al (112,113,136). I registered the record only once, being careful to avoid duplicates with the food premises list. For each introduced category, I revised the establishments' list with the foodscape postcodes. Then, for each identified establishment, I checked for duplication in the food and alcohol premises' lists. Some of the searches showed up repeated businesses. After this reiterative process, I identified 68 new food sources that were added to the foodscape database, regardless of their food classification. I found six records (food sources) without street numbers. This situation had happened previously with some food sources within the Forge Shopping Centre and the Market. In those cases, the food sources only appeared as a name in the complex, a street, and a postcode. To complete the missing data, I searched the name of the outlet in the Forge websites (137,138) and once I confirmed their existence, I added the Forge street number and the unit number within the complex when it was available.

Other searches

After finishing the traditional food sources search, I conducted a specific and separate search of food aid sources. Food banks are considered non-traditional food sources, they do not function as standard food outlets selling food products (113,134,135). The increased number of these food sources highlighted more than ever that low income individuals / families rely on these types of 'social benefit' resources following several years of government cuts and changes to the welfare system (139). They commonly offer a foodstuff basket but without payment, as a form of social support and benefit. As a food source, I incorporated them into the foodscape database. Thus, I revised the food banks postcodes in the area, found through two web pages to which I had

free access: the Trussell Trust and the Independent Food Aid Network (IFAN) (130,131). The Trussell Trust represents approximately 60% of the food banks in the UK and IFAN represents smaller networks and other independent food banks in the country. The Trussell Trust is a national network, which supports food banks and supplies emergency food to provide a minimum of three days' nutritionally balanced emergency food to inhabitants who have been referred in crisis. IFAN is a network that supports all of the independent food aid organisations in the UK and provides a similar package to the Trussell Trust.

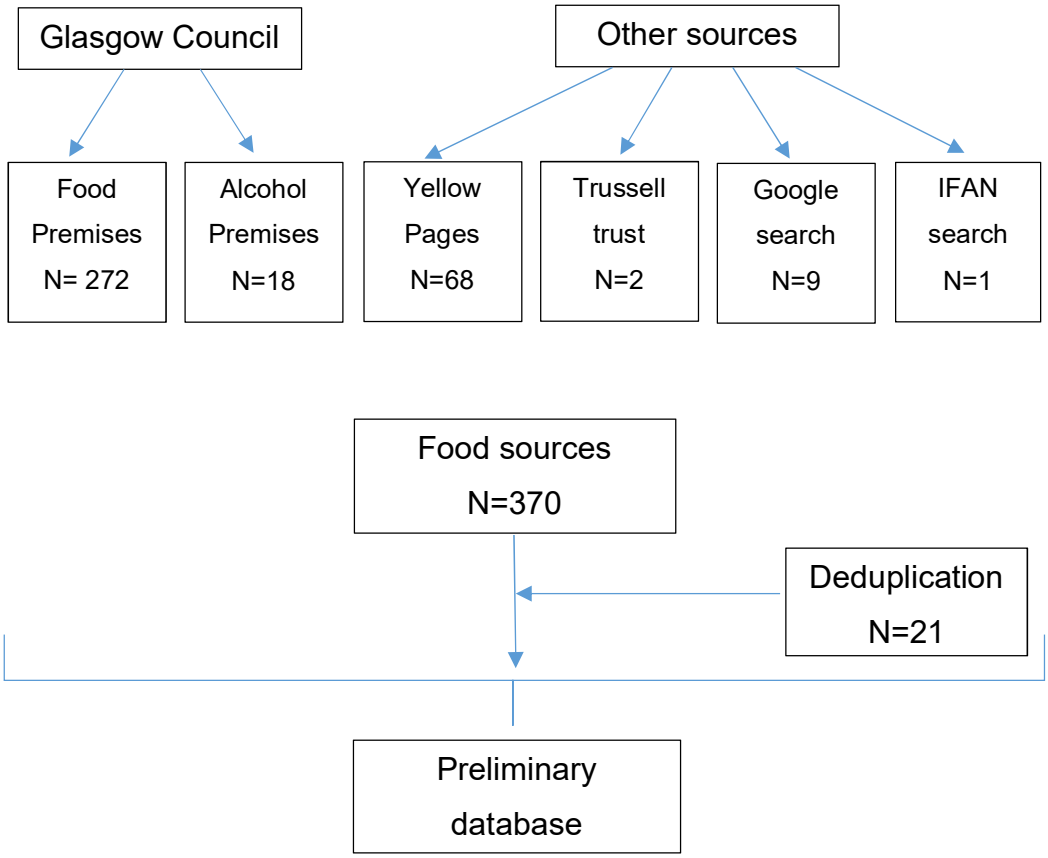
I developed the searches during June 2018. Food banks are not usually included in the food or alcohol premises records or commercial directories. To find them, I established a preliminary search to identify the main organisations related to this topic. I found that the Trussell Trust and the Independent Food Aid Network (IFAN) represented the majority of the food banks in Glasgow. For this reason, I contacted a representative of the Trussell Trust to request information about the names and locations of the associated establishments. After a telephonic communication, I received, via email, a report of the organisation and the official website where to look for the food sources. I used the Trussell Trust's website search section to locate a foodbank map of the UK. I also searched in the IFAN webpage for a map of the independent food aid network members (131). Both maps displayed the points where the centres were located, including their names and postcodes. Three food banks were located, two from the Trussell Trust website and one from the IFAN website. I also conducted an online exploration through Google, using the British version of the search engine and the following search terms: a) "food banks", b) "food aids", and c) "charity shops" which yielded four more food aid centres within the neighbourhood run by the Salvation Army. The Google search engine also identified four additional new food sources which were added to the database. All the found records were complete.

5.3.2.3 Foodscape database set up

After extracting the data from each directory and food source, the first version of the foodscape database was established. Figure 9 presents data of the

database construction and summarises the number of food sources collected from the different lists and directories. As can be seen, the dataset was composed initially of 370 records; however, after the de-duplication process (N=21) that total was reduced to 349. The main data source was the Glasgow Council, which provided 83% of the sample.

Figure 9. Foodscape database construction



The main source of duplication came from two records registered under different names but with the same address and classifications. Sometimes they showed a smaller difference in the names or were registered by commercial and/or fantasy names. Some food outlets were registered in the Council within the Shopping Complex, but in the Yellow Pages telephone directory they appeared just with the street name and number.

Finally, I added the coordinates to each food source. The data included the eastings and the northings for each establishment. To achieve this goal, in

August 2018 I searched into the AddressBase® Plus Excel file to find the required information. To access this database, I signed a research agreement with the Ordnance Survey. As a result, I was able to collect the required data to geo-localise the food sources at a later date. Street vendors appeared in the council list registered by the address where they usually store their kit; as a result there was no record of where they do their food selling. Their locations were pending until the fieldwork validation was completed.

5.3.2.4 The food source categorisation

As a last step to complete the preliminary database, I categorised the food sources. After examining the classifications used in previous studies, together with Glasgow Council's own classification, I decided to use the 21-point classification tool proposed by Lake et al in 2010 (113). Lake et al developed this food classification system in 2008, based on the previous public and commercial categories, as well as a field validation.

Table 4. 15-point classification tool

Food source categories
1. Restaurant, pubs and hotel restaurants
2. Pubs no food
3. Sit In café/coffee, specialist and sandwich shop
4. Takeaway café/coffee, specialist and sandwich shop
5. Baker - Retail
6. Takeaway and Fast Food
7. Supermarkets
8. Convenience outlets
9. Specialist (Purchase to takeaway only)
10. Mobile food and market
11. Vending machines
12. Non-food stores
13. Entertainment
14. Health and leisure
15. Closed/Private food outlets

Source: The foodscape: classification and field validation of secondary data sources (113).

The classification provides a tool to collect the entire foodscape, including peripheral categories (113). It was very similar to Glasgow Council's classification and it is particularly able to capture hidden food sources.

To access the classification, I contacted the corresponding author via email to express the formal intention to request the full classification with the 21 categories and 77 subcategories. The author sent (via email) a new version of this classification that contained 15 food outlets categories and 104 subcategories. Each category included constructs with definitions and features of each one. The list of categories is shown in Table 4. The list of the corresponding subcategories can be found in Appendix 7.

This newer 15-point classification has a higher number of sub-categories compared with the FSS, which has 82. It also has a more indepth description of sub-categories and permits to identify food swamps and food deserts, due to incorporate in the classification, the type of food outlets that permits to confirm both scenarios. Additionally, the classification has been cited in the Geo-Fern article as a good example of a validated classification (112). Burgoine et al. used this classification to explore the community food environment in Cambridgeshire in 2012, based on the Fenland study population (104). The authors used seven food outlet types, selected from the classification system suggested by Lake et al. that represented 68% of their foodscape. Burgoine et al. did not report any limitations in the classification system or in the categorisation process (104).

This exercise helped me to identify the type of food exposure I was likely to find in my sample, as well as providing me with a first-hand approach for the final classification. I used these data during the audit to confirm or modify the categorisation during the fieldwork, informed by the consumer food environment' characteristics. As I mentioned in sub-section 5.2.3, and as it appears in Table 5.2, I classified the food sources using the 15 categories and 104 subcategories of the 15-point classification tool, created by Lake et al. (113). From the total of sub-categories, 51 corresponded to peripheral classifications, which is almost half of the classification system. Examples of these subcategories are pubs, petrol stations and convenience off-license shops.

Geo-Fern guidelines recommend describing in detail: i) how the classification system was developed, ii) how the categories were grouped and iii) the constructs which inform each category (112). The classification system by Lake et al. was created to record and describe community food environments and is based on a combination of intermediate and direct methods (113). Among the intermediate resources, the authors reviewed the Newcastle City Council food premises list and online Yellow Pages directories. As a direct method, the research team chose field validation. After a combined data collection, the researchers built a system with clear construct definitions. The system was enriched with direct observations of the outlets from outside (photos) and inside. This approach considerably improved the classification and enabled the assessment of a group of constructs as a proxy for food availability within the consumer food environment (food sources) through using an audit checklist (112). In general these constructs are very clear and made precise by key words and so those constructs were also the ones I used. “Restaurants” was the only category which I thought required a complementary definition as the constructs were not sufficiently self-explanatory and did not necessarily represent the characteristics of these particular types of outlets. The sub-categories were grouped by the type of retail outlets primarily selling food (i.e. supermarkets and convenience stores) and outlets focused on service or out-of-home food (i.e. restaurants and takeaways). The constructs within each sub-category were expressed as key features of each type of food source and changed depending on their characteristics. Each sub-category had a range of one to four constructs that defined the subcategory type. These categories were: i) the establishment’s features (floor space, type of infrastructure), ii) staff (the number of employees), iii) types of food on offer or products (candies, sandwiches, formal meals, fast food, etc.) and in some cases and iv) the payment method (cash, credit cards, etc.), v) the opening times (only mornings or after 5 pm).

To categorise a food source, I confirmed the status by checking all the constructs of each sub-category. However, at the stage before direct observation, I was only able to categorise food sources based on the available

resource and database information. To categorise in a more complete way, I searched for methodological criteria to support the classification process (72,112,122,134), and finally, I decided to use the following strategies:

- *Analysis of the food source names*: to identify the most suitable category, I analysed the information associated with the names, which in the majority of cases provided sufficient information to locate the category. The names usually incorporated the type of business or referenced constructs associated to some sub-categories. This fact was most common in takeaways with delivery options, where outlets' names were linked to constructs: for example, category 6 “takeaway and fast food” and subcategory 6.2 “takeaway with delivery collection”.

- *A quick search using Google applications* and search engine revealed that some of the previous strategies were not sufficient to confirm or change categories. In these cases, I used other resources to collect more information of the establishments. I navigated through Google maps and Google Street views to find a database for outlets’ descriptions. Usually, the first result of the search dropped the food sources websites and/or Facebook pages and in the case of Google maps and street views, I was able to visualise the street location and see photos of the establishments. Examples include the application of this strategy to food outlets within the Forge complex, the shopping centre and the market.

- *Preliminary visits to the research setting within the city*: I undertook several visits to the city and to the setting, with the purpose of confirming the outline for the fieldwork pilot. This step helped me to become familiar with the community food environment and adjust the walking route. These trips were experientially valuable, helping gain experience of the culture of the study area, which aided categorisation. These field study observations allowed an acknowledgement of the local points of interests, the most important commercial streets, the ways in which residents behaved socially, including indicators such as apparel and communal activities in

the streets. All the information gathered during such exploratory visits supported a more in-depth design and field validation.

- *Use of the researcher's background*: a final strategy I adopted was to use: a) my professional expertise as a nutritionist, b) my personal experience as a customer and c) my knowledge in the food business to discriminate the category or sub-category in some situations. Researchers' experiences have been described in different papers as one of the key strategies to help develop required categorisations. Personal skills helped me to identify businesses characteristics, such as names and products and branding e.g. through national chains of supermarkets and other outlets.

- *Obesogenic approach and prioritisation of the type of food offer construct*: the GEO-Fern guidelines identify the importance of understanding the prioritisation of the constructs to be classified (112). Fifty-two sub-categories describe different food offerings and almost half of them (twenty-four) are related to less healthy or high-energy dense food. These categories are a key aspect of this research as the study sought to evaluate the obesogenicity of the community food environment through the spatial analysis of healthier and less healthy food sources, as a proxy for obesogenic food availability. Thus, in cases where this construct (healthy and less healthy characteristics) was part of the sub-category, I paid special attention to identify if it was present, or not, in order to confirm or change its classification. In some categories, this decision was relatively easy, as it was recognised immediately as an unhealthy food source; for example, fast food outlets. However, in other situations with mixed offerings, such as cafes, I took special care to analyse the nature of the café and its culture. According to my experience in the fieldwork, cafes used to offer fried, high in fat and high in sugar food (bakery, greasy sandwiches and rolls, sugary beverages, etc.). In these cases, this construct was prioritised over the other two that were part of the sub-category.

Using this classification template and the strategies mentioned above, I analysed the food sources database individually. I incorporated these data into the foodscape database using three additional Excel columns: i) a 15-point category, ii) sub-category and iii) code, as well as keeping an additional observational record on the constructs used to classify each source for replicability (112,113).

Data previously classified were used to confirm food source types during the validation process. After this comprehensive checklist and validation strategy, I had no missing data, with all records fitted into a category and sub-category. I cleaned the dataset by further checking categorisation; as a result, I eliminated three records that *a priori* confirmed they were not selling and/or offering food to the public: i) a margarine factory, ii) a wholesale food supplier and iii) a staff canteen. This decreased the study sample to 346 records. Once I finished the refinement, the first version of the foodscape database was ready to be validated via fieldwork.

5.3.2.5 Database fieldwork validation

As a final stage, I carried out fieldwork to explore directly the community food environment. This step constituted one of the most important stages of this research project. It offered me the possibility to directly observe the neighbourhood and experience the real community and consumer food environment as a customer, health worker and researcher. While the main objective was to validate the food sources, there were other variables particularly relevant to observe. I determined the location of main commercial streets, points of interest and street vendors. I also obtained in-store valuable information, such as food sources menus, special offers (particularly those related to football matches) and opening times for almost all the audited sample. This information was not included in the secondary databases; however, to obtain such data was crucial to improve the food source classifications and to better understand the 'food exposure' in the area. During the validation, my primary focus was on the corroboration of the name, location

(address and coordinates) and classification of the food sources included in the preliminary database. A second objective I developed in parallel was to identify any outlets that were closed, non-existent or new in the foodscape area.

To design this stage, it was necessary to study the area through a geographical lens, search for other similar studies' protocols and request information from other organisations and researchers (113). I visited Whitewood to confirm the setting and make sure the protocol considered all the research elements for the fieldwork. In parallel, I read other studies to identify their protocols and search for missing steps or new insights I might need to consider (112,122,134). I included key documents such as the Geo-fern checklist and Lake et. al protocol. Such information highlighted the importance of identifying new and closed sources, and suggested sections to include in the survey sheet design. In addition, I contacted researchers and public health survey managers to refine the audit plan.

Holding expert information meetings with researchers from Glasgow University's Centre for Research on the Environment, Society and Health (CRESH) was helpful in ascertaining context. Glasgow Health and Wellbeing Survey managers, who had carried out research in areas of deprivation in the city, endorsed my audit plan. They emphasised the importance for a researcher to first picture the foodscape spatial dimension and then to divide it, taking into account the sample and the points of interest. I established a final e-communication in parallel, prior to meeting the executive director of the European Healthy Stadia Network & Health Equalities Group. He and other researchers within the group advised me to use a mystery shopper profile. After the preliminary visit, a brief literature search review, experts' advice, and the analysis of the documents facilitated by Dr. Lake, I designed the fieldwork plan (Appendix 8), including the route map, the survey sheet (Appendix 9 Survey sheet

N° GPS N°

Date ___/___/___ Time ___:___

Open: Yes/ No

Photo: Yes/ No If the answer is no, register again:

Date ___/___/___ Time ___:___ Open: Yes/ No Photo: Yes/ No

Food sources data	Previous information	Field Validation
ID/Code		
Name		
Address and postcode		
Food source N° & category*		N°___
Food source N° & subcategory*		N°___
Opening times		
Opening days		

*Use the food outlet classification system (Appendix 1) to code the food source type (number)

Menu:	Chips	Fish
Chicken	Curry	Burger
Cheeseburger	Hot dogs	Sausages
Rolls/wraps	Chip & cheese	Pizza
Soup	Ice – cream	Pastries
Sandwiches	Nachos	Hot/Cold Drinks

Others:

_____

_____

_____

Category/subcategory description criteria: (size, sit-in and/or takeaway, cuisine type, available menu (healthier options), staff.

_____

_____

_____

~~Appendix 9~~) and a pilot to rehearse. I added a list of food sources to the protocol, grouped by geographical zones in concordance with the route map

and a printed version of the 15-point classification tool. The details of the data contained in each document can be seen in Appendices 9 and 10.

The pilot was carried out in August 2018 in a selected area of the neighbourhood and the buffer. I used: i) the protocol, ii) the list of food sources data, iii) the audit survey sheet, iv) the route map, v) a smaller printed version of the classification and vi) a GPS device. I chose that date to also capture some mobile food vendors' locations during a football match at the Celtic Park. Because the mobile food vendors' locations were registered by the Council in the place they are parked, and not in the place they usually use to sell, I brought the GPS device to measure their coordinates. Street food vendors have frequently been described as a source of less healthy fast food; thus, capturing their exposure was important. I conducted the pilot from 9:00 to 20:00 hrs, with a major football match being played in the afternoon. The selected area size had a walking distance of 9.3 km, which covered the distance to the research zone from the train station, including Celtic Park. I walked via Gallowgate Street to the buffer zone and checked every block on the route map. I used the GPS and Google maps app to check my exact position in the foodscape. I measured some outlets within The Forge shopping centre and buffer zone to test the protocol and GPS. I continued measuring food sources in another main street (Springfield Road) to finish in the surroundings of Celtic Park stadium before and during the football match. I audited 38 food outlets (buffer N= 11 and neighbourhood N= 23); 34 were part of the database and 4 were new food sources within the neighbourhood.

Following the protocol, I applied the survey sheet to each establishment. I measured the locational coordinates only in the case of the mobile food vendors and food sources with missing or non-explicit locations. From a distance of one metre or less from the façade of each location, I observed and recorded external characteristics before entering to record internal characteristics. Using a printed survey sheet, I registered the general information first, followed by the food sources name and location data. The data gathering finished with the category and sub-category descriptions. The

general information section was relevant for coding the food source(s), as well as to confirm if the food source was a new or previously identified record. This part of the research also incorporated the coordinates, so I checked if it was required or not to measure this data. In the case of closed outlets, I immediately rescheduled a second audit on a different date and time. In the next section, I registered the food sources data. I took special care in registering the name and location confirmation, due to differences in publicly available records (e.g. Yellow Pages/ council records) of some outlets' names or street numbers. I also tried to capture all the visible details to correctly categorise the food providing establishment. In the menu section, the checklist format helped to collate information. To facilitate the record of menu options, I added a set of preparations I discovered were very common in a wide range of outlets. I added webpages or any other information related to them (offers, social media adds, etc.). From this audit, I deleted seven food outlets: three had been closed down, one was not selling food and three were not found or were located outside the foodscape area. The findings were valuable in terms of the protocol improvement and the adjustment of the fieldwork.

I developed the fieldwork during August 2018, covered 142 food sources with 33 food sources audited per day, using the strategy of confirmation, discovery, deletion and a re-audit for a second confirmation. I collected data from 09:00 to 20:00 hours; a duration that allowed me to capture data from food sources opening in the late afternoon, such as some fast-food takeaways/deliveries outlets and pubs.

A total of 92 outlets were validated (neighbourhood= 74 and buffer N= 18) represented 36.1% of the sample, including the pilot. I identified 9 new outlets, but discarded 41 outlets for the following reasons: a) twenty-four were not found, b) eight had shut down, c) two had a foodscape postcode but were located outside the buffer, d) four did not sell food, e) two moved outside the buffer and f) one was not open to the public.

I audited all the mobile food vendors within the sample, entered 85 establishments and observed: i) the types of food offer, ii) opening times, iii)

menu, iv) types of cooking preparations and v) size portions. The menu and size portions were a useful part of the classification analysis; however, I did not analyse these data beyond a general description. I registered additional dishes or products if the establishment offered something more or a different alternative, i.e. Chinese takeaways.

Survey sheets from audited food sources were stored in a separated folder for the final analysis, after the online validation had occurred. Route maps and the rest of material were also stored to recreate the route I conducted during each day's research journey. The GPX files with the measured coordinates were downloaded from the GPS device to a digital folder. I transformed GPX into shapefiles and added them to the foodscape.

5.3.2.6 Online validation

After my fieldwork stopped because of safety reasons, I completed the final part of data validation through an online crosschecking of the pending food sources, in order to confirm: a) their existence, b) name, c) location and d) type of outlet. To conduct this final part, I reviewed other papers to identify search strategies. I designed a simple search strategy, which included exploring different type of websites to confirm as much information as I could about the food sources. Lake et al. had used online a Yellow Pages directory and Burgoine et al. used Google and Google street views to confirm physical locations and observe the sources' facades (104,113). In addition, to ensure comprehensiveness I added other popular customers' websites and the food outlets social media webpages, in order to confirm if the sources were still open or were closed. The current name, location and data to classify them were also recorded.

Data were extracted from these different sources: i) Google search engine, ii) Google maps app, iii)Yellow Pages, iv) popular customers' websites like zomato, yelp, Facebook and Instagram, v) outlets' webpages, vi) the Forge Shopping centre and vii) the Forge market official websites (140,141). In the majority of the cases, I also obtained opening times, menus and 'special offers'

information. The collected data was separated onto another Excel sheet, using the same domains as for the foodscape database.

I explored the 159 pending food sources to complete the database in September and October 2018. I deleted a further 60 records for the following causes: a) ten were shut down, b) four were not open to the public, c) twenty-nine were not offering food, and d) seventeen were not found. The remaining ninety-nine records were validated and added to the foodscape database for the final analysis and categorisation.

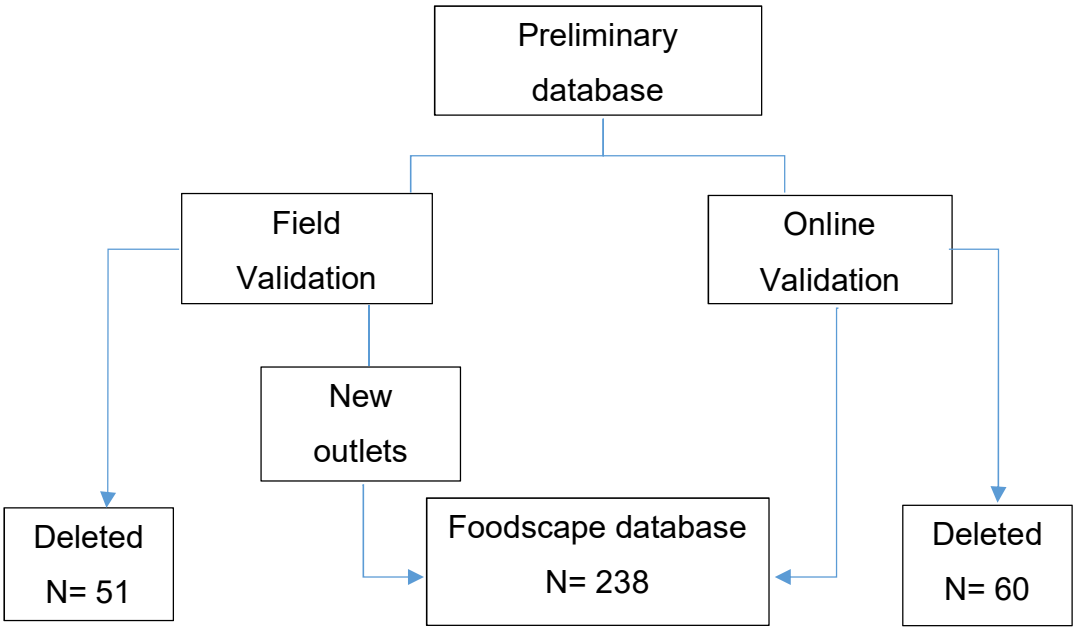
I recognise that by not being able to physically and visually verify the food sources in the space some may be missing as the final part of this research relied on an assumption that the food sources were digitally identifiable. Though I found the majority of them through digital means, undoubtedly not all of them were available, which limited my search and created a bias towards the "not found" records. Google street views, food outlets websites and customers' web pages did not always show updated information. This situation could give rise to an overestimation of open and active outlets that perhaps were in fact closed at the moment of the validation.

5.3.2.7 Database completion

Completing the foodscape database involved the addition of eight more columns: i) validation date, ii) type of validation, iii) changes name, iv) location v) type of business/source classification, vi) opening times, vii) menu and viii) new observations. In the case of the online validation, I added a final column for the online sources. As can be seen in

Figure 10~~Figure 10~~ after cleaning and completing the database, I obtained 238 validated records with 111 food sources being deleted. This represented 31.8 % of the preliminary database. Of those sources that were deleted: a) thirty-five were outlets not selling food, b) twenty-one had closed, c) forty-four were unable to be found, d) four were outside the buffer and e) seven were not open to the public.

Figure 10. Diagram with food sources validation



In terms of the categorisation, I re-analysed every food source classification by comparing the sub-categories' constructs from each record with the ones obtained during the field and online validation. With some records, I confirmed the previous classification and in other cases, I adjusted the sub-category within the same category or simply changed both categories and subcategories. I made changes in 37 records in total. Twenty-one records were changed from across sub-categories within the same category and sixteen changed to a different category and subcategory. Only ten records were reclassified after considering the type of infrastructure, whereas twenty-four were associated with a change in the type of food being offered and three were subject to changes in both their infrastructure and the types of food offered. In the case of the new food sources, these were classified after confirming the constructs and checking menus. Some categories, such as cafes and takeaways, needed more data to distinguish between a 'sit-in' and 'takeaway' café and takeaways providing a delivery/collection service.

I added the coordinates to the food sources with missing data. Three data issues emerged: i) new food sources, ii) establishments which were confirmed to be in other locations than what the public records said, and iii) the ones that were missing from AddressBase Plus. In the case of new food sources, I extracted the coordinates for thirteen outlets, from the GPX files into the foodscape database. The majority were mobile food vendors who had administrative addresses instead of commercial locations. For the establishments that changed location, I crosschecked the ten pending locations with AddressBase Plus and repeated the extraction. Finally, for the establishments whose addresses I could not find in the database, I located them manually using Google maps, contrasting each location with the base map layer. I did this procedure with three food sources. I added a new shapefile specifically to create points on the map layer based on the identified locations.

5.3.2.8 Food sources geo-localisation

Once I completed the database, I proceeded to crosscheck the coordinates. It is essential to start this section reporting the known positional errors that could affect the coordinates' measurement. AddressBase Plus uses an address points model where their measurements are assessed in the centroid of the buildings to which the address belongs. Their positional error is ± 0.4 m, which is considered very low; consequently, the measures are highly accurate. I also followed an address point model to capture the coordinates in the fieldwork. The GPS device Garmin model eTrex® 10device has a positional error of ≤ 3 m. However, I can confirm that I registered all the measures with less than ± 1 m of distance from the food sources. Although I did not have the chance to measure from the centroid of the food sources, these measures are still considered highly accurate in an urban context.

Geo-Fern guidelines recommend reporting any procedures that can affect the geocoding results (112). I found after the database revision that some food sources had repeated coordinates. Within the Forge Complex, 29 outlets shared the same pair of coordinates. The situation was repeated in the neighbourhood, where another other seven pairs of outlets shared the same

coordinates. Within the Forge Market, there were 14 other sources with repeated coordinates. This ‘compression’ situation appeared again in the Forge Retail Park, where I found two pairs of outlets with the same coordinates and in the buffer, there were nine pairs of outlets with the same location coordinates. Finally, one pair of mobile vendors shared the coordinates due to them being located very close together. In total, I had 58 food sources out of 238 with repeated coordinates. This meant that 24.3% of the sample was invisible in the map and therefore areas like the Forge complex, where the exposure is considerably higher than other zones, would be under-represented in the calculations.

To address this issue, I applied a method known as ‘jittering’. ‘Jittering’ has been described as the act of adding random “noise” to avoid over plotting of values; a technique usually applied to statistical graphs (121,142). Over plotting happens when a set of values is rounded to a convenient unit. In this case, it means that multiple food sources are overlapped with the same coordinates’ values. Using this technique, it was possible to "spread" the points using a random pattern (normal distribution) to obtain enough distance between them (121,142). This intervention changed the food sources coordinates’ values and moved their position on the map sufficiently to become visible. As a result, this manipulation enabled each overlapped food source to be counted and measured within the calculations. The followed procedures can be seen in Appendix 10.

Once all the food sources were geocoded, I differentiated the 15 main categories of food sources with a different colour on the map. Subcategories were not distinguished due to, in many cases, being too small to become easily identifiable on the map.

5.3.3 The foodscape features

Using the spatial analysis, I calculated the prevalence, proximity and density of food sources by category and sub-category type to describe the general features of the foodscape.

5.3.3.1 Predominance calculations

Definitions:

Prevalence refers to the number of food sources by type (and subtype) within the study area (40,49,106)

Table 6 shows the distribution of food sources into the foodscape. I created the table with descriptive statistics using SPSS. The sample was separated into the 15 main categories and 39 sub-categories, showing the frequencies and percentages of each one. This procedure was achieved manually using simple formulae, in a separate Excel sheet within the foodscape database file, dividing the predominance within the neighbourhood and the buffer.

To evaluate statistical differences in the food sources distribution, I ran the Kolmogorov – Smirnov test. I additionally applied the Wilcoxon test to assess the difference in the food sources distribution patterns between the neighbourhood and the buffer

5.3.3.2 Proximity calculations

***Definition*:**

Proximity refers to the distance in kilometres of sources to the centroids of spatial units of analysis, commonly represented by residential areas (40,49).

To calculate the proximity of food sources to a residential area the centroid of the residential area needs to be identified. Fortunately, for my study site the foodscape and Whitewood neighbourhood have a geographical and natural centre, located in an empty space. This situation allowed me to measure the distance from the centroid to the outlets. Different proximity measures, reported in the literature, using Excel and QGIS were calculated to combine

the analysis of accessibility: the first were the general mean distance and mean distance by category. As a significant proportion of outlets of all categories were close to the centroid, and also located near the buffer's edge, the mean distance measures were not able to the detect differences in proximity in a general way, or by type of food outlets.

Therefore, it was necessary to use the QGIS tool, named the "shortest path"(121) to calculate walking distance. This is a network spatial analysis tool, which calculates the shortest distance between two points. The food categories were divided into eight ranges of walkable distance every 300 meters, based on the minimum and maximum distance: 0 to 299, 300 to 599, 600 to 899, 900 to 1199, 1200 to 1499, 1500 to 1799 and 1800 to 2100.

After obtaining the frequencies, I used the Kolmogorov-Smirnov test in SPSS to analyse the differences in the distribution of observed frequencies across the eight distance categories. The analysis results, showing the frequencies distribution, are displayed in Figure 3, in section 6.3 of the results chapter.

The spread of food sources was concentrated in five points: i) the Forge Complex, ii) + iii) two other hubs of the commerce and services nearby the centroid and the Forge, and iv) + v) two other concentration points situated at the edge of the buffer. To describe the differences in distance, I measured the walkable distance from the furthest residential points to the five food sources concentration points. The residential points are displayed in table 8 in section 6.3 of the results chapter. The shortest path was calculated to obtain the walkable distance in kilometres.

5.3.3.3 Density calculations

The third descriptive foodscape variable calculated the density of food sources.

Definition:

Density refers to the concentration in terms of number of outlets within the study area, expressed by kilometres square (km²) (40,49).

The calculation provided the foodscape density as well as the neighbourhood and buffer food sources densities. I conducted a Wilcoxon test via SPSS to evaluate to the differences in the densities across the categories in both the neighbourhood and the buffer. Description of the findings and interpretation can be seen in section 6.4 of the results chapter

5.3.4 Assessment of healthier and less healthy food sources

5.3.4.1 Healthier and less healthy food sources re-categorisation

The description of the foodscape features enabled me to create two new categories based on the literature described in Chapters 3 and 4, personal knowledge and the experience gained during the fieldwork: a) healthier and b) less healthy food source categories. The purpose was to explore the obesogenicity of the community food environment and attempt to assess the level of “healthiness” of the food exposure. It was challenging to separate the outlets, given the preponderance of mixed healthy, less healthy and unhealthy products within the same establishment.

In order to create the foodscape I aimed to identify “healthy” products in terms of general quality and energy-dense characteristics by using the definition of “healthier food environment” and “healthier foods” developed by the BDA and CDC (27,28,143). Healthier food environments offer high levels of low and very low energy dense food, considered as “healthier foods"(27,143). As described in chapter 3, those offerings included: a) fruits, b) vegetables, c) whole grains, d) fat-free and low-fat dairy products, and e) seafood. Healthier foods are also those with less or minimal amounts of: i) sodium (salt), ii) saturated fats, iii) trans fats, iv) cholesterol, v) added sugars, and vi) refined grains. The “healthy” category also incorporates healthier beverages including: a) fat-free or low-fat milk and milk products, b) fortified soy beverages, c) other lactose-free products, d)100% juice, and e) water (143).

The category is composed by eight sources that I found offering healthier products: i) supermarkets, ii) greengrocers, iii) fishmongers, iv) health food stores, v) convenience traditional outlets, vi) restaurants and vii) wholesalers viii) delicatessen (143–146). In previous studies, these classifications were considered as “healthy” categories (93,97,101,146–148). However, due to some of these outlets also offering high-energy dense and/or unhealthy food, I followed the trend of other researchers and decided the classification should also be named “healthier”. Despite there being a mixed offering from the sources cited above, these outlets have at least a significant “healthy” section in the menu or in a few cases, they offer mainly healthy products, thus the included establishment is considered “healthier” than those included in other categories. However, this classification is an approximation for, although I visited almost all the healthier outlets, I did not / could not measure the in-store contents. Therefore, it is necessary to note that I cannot be certain that the proportion of healthier food was very high in all the establishments mentioned. The evidence have suggested that the businesses adapt goods’ in-store availability, considering multiple factors such as: i) profit margins ii) best-seller products, iii) local preferences, and iv) customers’ incomes (82,149).

Apart from greengrocers, all the other “healthier” establishments supplied a mixed offering. For example supermarkets and traditional restaurants had a higher healthy food proportion than traditional convenience stores (93,97,101,146). Although supermarkets sold unhealthy food items, they also commonly had sections for frozen and fresh fruits and vegetables, grains and seeds and low or medium fat dairy products (43,58,69,82,97,101). Traditional restaurants included in their menus salads, vegetarian dishes, fresh fruit juices and fruit desserts (148). Their cooking techniques includes alternatives to avoid fried food such as oven roasts, which take more time but allow chefs to prepare dishes with low-energy food (148). Traditional convenience stores often offer a selection of fruits and vegetables, legumes as well as low-fat and medium-fat dairy products (93,113,145–147). Health-food stores might focus on vitamins and minerals supplements; however, they commonly sell organic products such as dry fruit, milk, yogurts, muesli and cereal bars (113).

Wholesalers usually offer a wide variety of products, including grains, legumes, frozen and sometimes, fresh fruits and vegetables, as well as low and medium-fat dairy products (113). Greengrocers and fishmongers, on the other hand, are the only outlets I found in both the literature and in the few outlets within the foodscape, that mainly sell healthy products (41,43,43,109,145,146). Greengrocers offer mainly fruits, vegetables, seeds and dry fruits. In the case of fishmongers, I observed the unique store mainly sell frozen and fresh fish, seafood, and in lower proportion fish preparations, like fish pies; a very popular choice in the UK.

I followed a similar process to create the "less healthy category". I reviewed previous studies, the fieldwork notes and used my academic and professional knowledge (5,30,48,49,76,111,113,145). Despite their mixed-offerings, less healthy food sources sell mainly medium and high-energy dense foods; in many cases, the entire offering is “unhealthy”(30,37,48). I decided to use the same category name as other authors “less healthy” because, although such outlets are selling high-energy and unhealthy food, in some cases there is still a small proportion of healthier food available. One other important reason informing food classification is that, from an energy point of view, many products, like carrot cake or fish pies, could be considering less healthy, because they have higher levels of fat and sugar. However, even considering that point, they are not classified as “unhealthy” or health-damaging foods (27,30,40,43).

Taking into account the previous issues, I designed the “less-healthy” category, which is composed of eighteen classifications of the classification system (113): a) takeaways and fast food, b) convenience outlets, c) candy/sweet/chocolate shops, d) restaurants, e) sit-in and takeaways ‘greasy spoon’ type cafes, f) sandwich shops, g) clubs and associations, h) ten-pin bowling, i) sport-related pub/café, j) cinema, k) amusements, l) vending machines, m) large and small discount stores, n) gift shops, o) butchers, p) bakers, q) pubs and r) mobile food vendors. Takeaways and fast food outlets are well documented to be one of the major sources of high-energy dense and

unhealthy foods (8,104,107,111,145). Both the literature and fieldwork confirmed that such sources offer ready-made food with large portions of fried products, containing high levels of low-quality fat and other processed nutrients (30,83,104). Examples of such offerings include: i) fried fish, ii) fried chips, iii) extra-large burgers with and without high-fat cheese, iv) pizza, v) foot-long hot-dogs with a big amount of mayonnaise, ketchup and mustard vi) curry with sausages, and vii) greasy steak pies.

Usually takeaways and fast food outlets do not sell healthier options or there may be only one 'green choice', most likely mixed with a fatty dressing or sauce. Also on offer will be sugary soft drinks, such as the famous at national level "Irn-Bru". For desserts, large and fatty ice creams and sugary donuts or cakes(5,27,30,113,146). In lower socio-economic settings, there is only a small difference between this type of business and fast food restaurants (30,37,42,90,107). In higher-income settings, these outlets are likely to offer a wider range of preparations that could take more time to prepare. Nevertheless, in poor community food environments the majority include the same types of food that are available from takeaways, as a part of their basic menu (5,48,61,107,111). Additionally, takeaways and fast food outlets offer other preparations such as stews or national dishes that are very caloric and dense in fat, such as fish and chips or haggis (150). The same situation is repeated in pubs offering food where they sell fish and chips, all types of burgers and the majority of the preparations mentioned above (113). The only difference is that a pub's focus is on selling alcohol and not the "sides" or products that complement the customers' alcohol consumption. A sport-related pub/café is a variant of pub but which incorporates coffee into the menu. Their focus is to broadcast sports matches, as well as F1 and major horse races (113).

According to classification system. clubs and associations can also be considered, in a food context, as similar to a pub, but with a more restricted menu based on fish and chips, burgers and alcohol (113). They open during some, but not necessarily all, days of the week and usually in the evening or

for special celebrations. Sit-in, takeaways and ‘greasy spoon’ type cafes, change the focus to tea or coffee, instead of alcohol (113). They also have a similar range of offers as the takeaways, fast food restaurants and pubs (113). However, these cafes can sometimes change the variety of the fast food on offer to more give space to sandwiches, including large paninis, full of high-energy dense ingredients and a wider variety of greasy bakery products. The classification system also considered sandwich shops as a variant of takeaway cafes but with a wider range of sandwiches being offered, all the items being rich in empty calories and large in size. Sandwich shops_can play with the focus on beverages and have many alcohol and coffee options (113).

Convenience outlets sell a wide range of products (52,55,56,66). However, according to the direct observation they often do not have available fresh food or such produce is limited to two or three items, such as apples, potatoes and carrots. Instead, their offers include plenty of sweets, greasy bakery items, soft and alcoholic drinks and other high-dense caloric foodstuffs (55,56,151,152). Sometimes these outlets also include fried and cold Indian or Middle - Eastern appetisers and processed chips as snacks. Bakeries in low- income settings offer a good variety of bread types but also many types of cheap, fatty and sugary pastries and bakery products (113). Bakery products comprise of donuts, cakes, rolls with cream, pizza and other type of baked snacks (113). Butchers usually sell fresh meat and meat products but as I observed during the pilot, the outlets offer mainly high-fat meat, entrails and different sausage products, as well as ‘greasy’ steak pies (113). Butchers also offer other preparations ready to fry, like meatballs, beef scallops and pork croquettes. I consider the butcher category as “less healthy” due to almost the complete food availability from these outlets in Whitewood was focused on a mixture of less healthy food and high-energy dense products, such as high-in-fat hamburgers and steak pies. Candy shops and gift outlets commonly sell a wide range of sweets and chocolates to attract both children and adults; a situation similar to vending machine offerings, which demonstrate a particular focus on sweets and processed caloric snacks (66,113).

There are three entertainment-related classifications included in this category: i) cinemas, ii) amusements and iii) ten-pin bowling. Despite the main purpose of these establishments not being related to food, they are a source of large portions of fast food, such as: i) popcorn, ii) caramels, iii) chocolates, iv) burgers, v) tacos, vi) pizzas and vii) soft drinks (37,40,41,113,146). These items are sold at cheap prices and are ready to eat during the time spent in the establishments (66,82,113,115). Ten-pin bowling and amusements also add alcoholic beverages to their menus. Large and small discount outlets are full of cheap and high-energy food offers. They include a wide range of: a) snacks, b) sweets, c) chocolates, d) cakes and e) highly caloric processed food. They can also offer family size 'combos' of these products at an economical price (61,82,90). Mobile food vendors are the last classification in this category. These vendors offer 100% fast food and their menus include the same foods associated with takeaways and other similar businesses, but are sold in larger portions; usually in the form of fried preparations and low-quality products (113).

Not all the sample was re-categorised. Subcategories such as sit-in and takeaway traditional cafes, pharmacies, delicatessens and food offered in leisure and community centres were excluded from both categories. The reason for such omissions was these classifications often provide more balanced food offerings or there was not enough information to put them in one of these two categories. Food offered by pharmacies, which often sell supplements, could be neutral in terms of healthiness and energy-balance.

5.3.4.2 Predominance calculations

Description of frequencies and proportion of this category are in section 6.5 of the results.

I calculated an additional measure: the modified Retail Food Environment Index (mRFEI)(61,63,153,154). The mRFEI is a ratio of healthy to less healthy food retailers within an area. The mRFEI incorporates the concepts of "food desert" and "food swamp" into a single indicator (61,63,153,154). Food deserts were previously defined as areas with lack of access to affordable healthy

foods that provide and facilitate a healthy diet (47). The mRFEI is able to express how the community food environment might be a “food desert or food swamp”(153,154). A score of zero represents a total food desert or no presence of healthy food there (153,154).

The score and its interpretation are described in the section 6.5.1 in the results chapter. Procedures to calculate the mRFEI are described in Appendix 11 Procedures to calculate the mRFEI

The modified Retail Food Environment Index calculation (mRFEI)

I calculated an additional measure for the purpose of assessing the healthy and unhealthy offer of the food environment: this is known as the modified Retail Food Environment Index (mRFEI). The indicator was launched in 2011 by the Center for Disease Control (CDC)’s division of Nutrition (154). mRFEI is a ratio of healthy and less healthy food retailers within census tracts across each state. Food retailers are defined by typical food offerings in specific types of retail stores (154).

The healthy food retailers’ category includes supermarkets, large or traditional convenience stores, supercentres, and produce stores. (Supercenters are the equivalent of hypermarkets for example Cosco or Walmart (143,154). Less healthy food retailers category includes fast food restaurants and small convenience stores within census tracts. mRFEI reflects the percentage of the community food environment that is healthy, assuming that the rest of the exposure is less healthy. The mRFEI incorporates the concepts of the “food desert” and “food swamp” into a single indicator (154).

Food deserts were previously defined as areas with lack of access to affordable healthy foods that provide and facilitate a healthy diet (47). Food swamps were described as areas with a high exposure of energy-dense food options.” (48). Thus, the index is able to express how the food environment might be both a “food dessert or food swamp”. If the index scores zero, it represents a total food desert having no presence of healthy food at all. (154).

A score of one hundred represents a healthy food environment, with only healthy food sources in the area. Lower scores represent few healthier food outlets and in addition, a food swamp or high exposure to obesogenic food pointing to areas where there are higher proportions of less healthy food sources compared to the number of healthy food retailers (154).

I adapted the index and included more food outlet classifications in both, healthy and less healthy categories. The study area used was the foodscape instead of a census track. To calculate the healthy food sources category, I included all the outlets of the healthier food sources category previously calculated. In comparison with the classifications included originally, in addition to supermarkets, wholesalers, convenience traditional outlets and greengrocers, I also incorporated fishmongers, health food stores and traditional restaurants. Regarding the category of less healthy food retailers, in addition to fast food restaurants and small convenience stores, I incorporated another fifteen classifications from the previous studies These included:: candy (sweet) shops, restaurants, sit-in and takeaways greasy spoon type cafes, sandwich shops, clubs and associations, ten-pin bowling, sport-related pub/cafés, cinemas, amusements, vending machines, large and small discount stores, gift shops, butchers, bakers, pubs and mobile food vendors.

I calculated mRFEI using the following formula (154):

$$mRFE1 = 100 \times \frac{\#\text{healthy food retailers}}{\#\text{healthy food retailers} + \#\text{ less healthy food retailers}}$$

The calculation was $= 100 \times \frac{23}{23 + 172} = 11.8$

~~Appendix 11~~.

5.3.4.3 Proximity calculations

To compare the proximity of both categories, I analysed the number of healthier and less healthy food sources by distance in the neighbourhood, buffer and the foodscape. I calculated the walkable distance of each food source contained in this new sample. As previously, I used the network spatial analysis in QGIS. Then, I distributed the measures in the eight distance categories, each 300 metres (as outlined above). I found differences in the distribution of healthier and less healthy food sources across the distance categories. To explore that information, I conducted a chi squared test to analyse the differences in the distribution pattern, using SPSS. Descriptions and interpretations of the findings are displayed in section 6.3 of the results chapter.

5.3.4.4 Density calculations

To compare the concentration of both categories, I first described the densities of each category across the study area. I followed the same procedure as before, dividing the number of food sources by the surface area in km². Then, I analysed separately the densities of food source classifications of each category in the neighbourhood, the buffer and the foodscape. Descriptions and interpretations of the findings can be seen in section 6.4 of the results chapter.

5.4 Sensitivity analysis of the food premises list

As it was suggested by Geo-fern guidelines, and following the same procedure suggested by Lake et al., I calculated the positive predictive values (PPV) and conducted a sensitivity analysis to validate the food premises list provided by Glasgow City Council (112,113). PPV is a measure of sampling precision and represents the percentage of data source outlets present in the fieldwork (112,113). Sensitivity analysis is a measure related to the sampling accuracy and evaluates the proportion of food outlets which were found in the field that

were correctly identified by the data source (112,113). The major source of addresses was the food premises directory cited above; the directory was my main database. I excluded online directories (Yellow Pages, IFAN and Trussell Trust) due to them representing only a small part of the total sample. I only compared the Glasgow Council's premises lists with the fieldwork and not the online validation, due to fieldwork being perceived as the acceptable gold standard for such a research initiative. The online validation was an alternative for pending records' confirmation, but such an approach is not as accurate as fieldwork.

By using Excel, I calculated the sensitivity and positive predictive values (PPV), guided by the equation in Table 5:

Table 5. Positive predictive values (PPV) and sensitivity calculations

	Fieldwork		
	Outlet present	Outlet absent	
Glasgow food premises list			
Outlet present	True positive (TP)	False positive (FP)	PPV=TP/TP+FP
Outlet absent	False negative (FN)	True negative (TN)	
	Sensitivity = TP/TP = FN		

Source: The foodscape: classification and field validation of secondary data sources (4).

True positive values are the records that were confirmed during the fieldwork and were listed in the premises' lists. 'False positives' are: a) the number of food sources that were listed but were not found or b) were closed during the field validation. 'False negatives' are the records of outlets not listed but are actually present on the fieldwork. An ideal PPV would be 100% meaning that all the Glasgow Council food sources listed were present in the fieldwork. The PPV score in this case was 91% and sensitivity was 89%, meaning the list was highly accurate and precise.

5.5 Ethical Approval

A level 1 ethics form was submitted online to the Usher (UoEd) ethics review group in March 2018. The form is a self-audit checklist to inform a level 1 ethical review. According to the Centre for Population Health Sciences, 'Level

1 only' studies do not required formal reviewing. The document is displayed in Appendix 12.

Chapter 6 – Results

This chapter contains the results of the data analysis. The objectives of the chapter are:

- to explain the most relevant characteristics of the foodscape
- to present the main findings of this research

It is divided into five sections in concordance with the proposed research aim and objectives.

section 1 focuses on a general description of the foodscape geography, including the spatial representation of the food sources by category and subcategory.

section 2 describes the predominance of the different type of food sources within the neighbourhood and the foodscape and the modified retail food environment index (mRFEI) results

section 3 describes the proximity findings by type of food source within the neighbourhood and the foodscape

section 4 reports the density of the different type of food sources within the neighbourhood and the foodscape

section 5 depicts the predominance, proximity and density of the healthier and less healthy food sources findings.

6.1 – Geography of the foodscape

As it is displayed in the Foodscape map Figure 12, from a spatial analysis perspective, Whitewood and the buffer area compose the foodscape. The Buffer includes zones of the surrounding neighbourhoods: Carntyne, from the North, in the top of the foodscape; Tollcross in the East side of Whitewood; Bridgeton in the West side and Dalmarnock by the South, in the bottom of the foodscape.

Whitewood is represented by a 1.5 kilometres square (km²) zone in the centre, delimitated in the map by a black line. **The buffer** is shown as a 6.4 km² circle contained by a black line. Together, they conform the **foodscape**, which covers an area of 7.9 km².

Figure 11 Photo of the neighbourhood

(Taken by the author)

The **geographical centre** has been drawn as an orange pentagon, and it is located in the centre of the neighbourhood residential areas, in an empty and abandoned property.

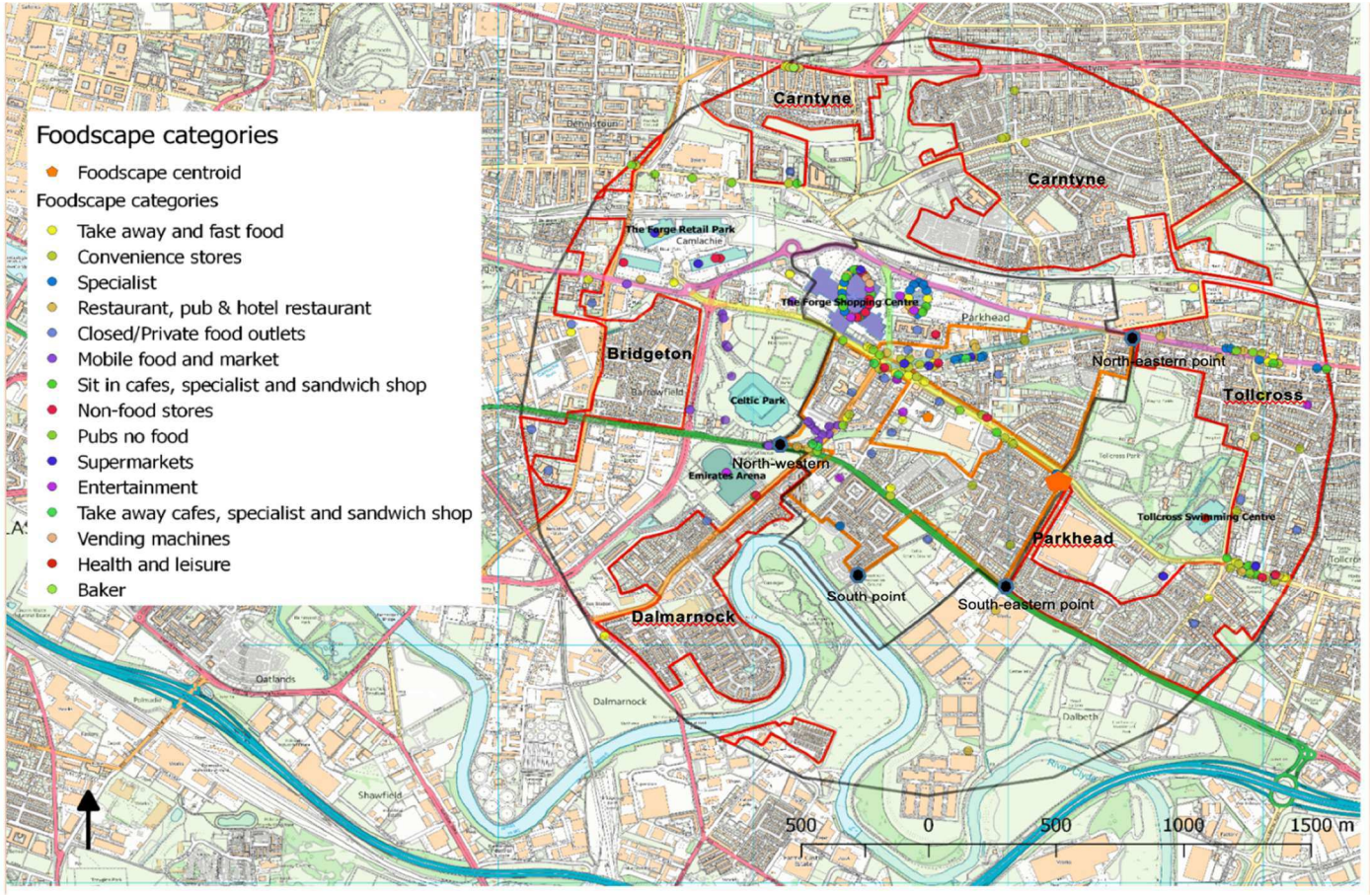
Seven residential areas can be distinguished in the foodscape: two in the neighbourhood around the centroid, delimitated by an orange line, and other five in the buffer, delimitated by a red line. One residential area in Whitewood is located in the North side of the neighbourhood and the other is located in the South side below the centroid. Regarding to the buffer residential areas, there are two parts of Carntyne, one part of Tollcross, one part of Bridgeton and one part of Dalmarnock.

Both Whitewood and the buffer zone have six commercial streets that can be easily distinguishable in the map. Three streets cross horizontally almost the entire foodscape: Shettleston road, Gallowgate (and its continuation Tollcross road) and London road. Shettleston road is located nearly the upper limit of the neighbourhood in purple. Gallowgate and Tollcross road are depicted in yellow and cross just in the middle of the neighbourhood and the buffer. London road is represented in green and is located in the lower map area. Westmuir Street, Duke Street, and Springfield road go from north to south, and they are located in the mid-upper area within Whitewood. The streets and other details are identified in the base map in the Appendix 13.

The foodscape is composed of 238 food sources. The neighbourhood contained 143 (60.1%) and the buffer 95 food sources (39.9%). In terms of type of food sources, 15 categories and 39 subcategories were identified. The 15 main categories are displayed in Figure 12, characterised by multicolour points. The categories are the following: 1) takeaways and fast food outlets, 2) convenience stores, 3) specialist stores, 4) restaurant, pub & hotel restaurant, 5) closed/private food outlets, 6) mobile food and market, 7) sit in cafes, specialist and sandwich shops, 8) non-food outlets, (where primary aim is not food related) 9) pubs without substantive food, 10) supermarkets, 11) entertainment–related stores, 12) takeaway cafes, specialist and sandwich shops, 13) vending machines, 14) health and leisure related stores and 15) bakeries.

As it can be seen in Figure 12, the Forge shopping retail park is located in the Northwestern part of the buffer, whereas the Forge shopping centre and the Forge market are located within the neighbourhood. The food sources within the shopping centre and the market contained 26 and 12 food outlets respectively displayed in two rings.

Figure 12. The Foodscape



6.2 – Predominance of the food sources

As it is displayed in Table 6, the most predominant types of food sources within the foodscape and the neighbourhood are the takeaways, fast food outlets and convenience stores, which together represent approximately one-third of the total food exposure in the foodscape (33.6%;n=80) and in the neighbourhood (29.4%;n=42).

Specialist outlets are also present in high prevalence in both the foodscape (10.5%; n=25) and the neighbourhood (13.3%; n=19). Among the specialist subcategories, butchers (2.8%; n=4), bakers (2.8%; n=4) and candy outlets (2.1%; n=3) were more prevalent in Whitewood than the buffer area.

The category of restaurants, pubs & hotel restaurants were proportionally lower in the neighbourhood (8.4%; N=12) than the foodscape (10.1%; N=24). However, the traditional restaurant with takeaway/delivery option subcategory was higher in the neighbourhood (3.5%; n=5) than the buffer and the whole foodscape, whilst the subcategory pub fast-casual restaurants were more predominant in the buffer (6.3%; n=10) than the neighbourhood (2.8%; n=4).

The categories closed/private outlets represented 7% (N=10) of the food sources in Whitewood and 8% (N=9) in the foodscape. The subcategory charitable organisations made up 2.8% (N=4) in the neighbourhood, followed by community centres which represented 1.4% (N=2). “Take away cafes” represented 7% of the food sources (n=10), within Whitewood and their presence was similar in the foodscape (7.1%; N=17). The category of “Mobile food and market” vendors was considerable with 11.9% (N=17) in the neighbourhood whereas the presence in the foodscape reached only 7.6% (N=18) “Non-food stores” also represented a lower proportion than mobile vendors within the foodscape (6.7%; n= 16) and the neighbourhood (6.3%; N=9). The subcategory “pharmacy” was the most common, representing 3.5% (n=5) of the food sources within Whitewood

In lower prevalence categories, those of “Entertainment related outlets” and “Supermarkets” constituted 4.9% (n=7) and 2.8% (n=4) of the neighbourhood respectively. Within the entertainment category, the most numerous outlets were “Amusements” (2.1%; n=3) and “Bowling” centres” (1.4%; n=2).

The least predominant category in Whitewood was “Vending machines,” (0.8%; n= 2). Finally, the categories “Health and leisure” (0.4%; n=1) and “Baker” (0.4%; n=1) were only present in the buffer zone.

Table 6. Food sources predominance in the foodscape

Categories	Subcategories	Neighbourhood		Buffer		Total	
		N	%	N	%	N	%
Take away and fast food	Traditional take away	9	6.3	13	13.7	22	9.2
	Traditional take away + delivery/collection	2	1.4	4	4.2	6	2.5
	Traditional take away with seating	7	4.9	3	3.2	10	4.2
	Instant fast food	3	2.1	1	1.1	4	1.7
	Subtotal	21	14.7	21	22.1	**42**	17.6
Convenience	Traditional	12	8.4	13	13.7	25	10.5
	Newsagents	5	3.5	3	3.2	8	3.4
	Off-license	4	2.8	1	1.1	5	2.1
	Subtotal	21	14.7	17	17.9	**38**	16.0
Specialist	Candy/sweet/chocolate shops	3	2.1	1	1.1	4	1.7
	Health food stores	3	2.1	0	0.0	3	1.3
	Greengrocer	2	1.4	0	0.0	2	0.8
	Fishmonger	1	0.7	1	1.1	2	0.8
	Butcher	4	2.8	2	2.1	6	2.5
	Baker	4	2.8	1	1.1	5	2.1
	Delicatessen	2	1.4	1	1.1	3	1.3
	Subtotal	19	13.3	6	6.3	**25**	10.5
Restaurant, pub & hotel restaurant	Traditional	0	0.0	1	1.1	1	0.4
	Traditional with takeaway/delivery option	5	3.5	1	1.1	6	2.5
	Fast casual	2	1.4	3	3.2	5	2.1
	Pub fast casual	4	2.8	6	6.3	10	4.2
	Buffet	0	0.0	1	1.1	1	0.4
	Hotel restaurant	1	0.7	0	0.0	1	0.4
	Subtotal	12	8.4	12	12.6	**24**	10.1

Table 6. Food sources predominance in the foodscape

		Neighbourhood		Buffer		Total	
Categories	Subcategories	N	%	N	%	N	%
Closed/Private food outlets	Charitable organisations	4	2.8	2	2.1	6	2.5
	Wholesalers	0	0.0	1	1.1	1	0.4
	Community centres	2	1.4	1	1.1	3	1.3
	Clubs and associations	1	0.7	0	0.0	1	0.4
	Hospitals	1	0.7	0	0.0	1	0.4
	Education/Carers	2	1.4	5	5.3	7	2.9
	Total	10	7.0	9	9.5	**19**	8.0
Sit in café/coffee, specialist and sandwich shop	Traditional café	6	4.2	5	5.3	11	4.6
	Greasy spoon types café	4	2.8	2	2.1	6	2.5
	Total	10	7.0	7	7.4	**17**	7.1
Mobile food and market	take away food	17	11.9	1	1.1	18	7.6
	Subtotal	17	11.9	1	1.1	**18**	7.6
Non-food stores	Pharmacy	5	3.5	4	4.2	9	3.8
	Large discount stores	1	0.7	2	2.1	3	1.3
	Small discount stores	2	1.4	0	0.0	2	0.8
	Sport shops	0	0.0	1	1.1	1	0.4
	Gift shops	1	0.7	0	0.0	1	0.4
	Subtotal	9	6.3	7	7.4	**16**	6.7
Pub no food	Pub no food	6	4.2	7	7.4	13	5.5
	Subtotal	6	4.2	7	7.4	**13**	5.5
Supermarket	Large multiple	1	50.0	2	2.1	3	1.3
	Small multiple	3	2.1	1	1.1	4	1.7
	Discount	0	0.0	1	1.1	1	0.4
	Subtotal	4	2.8	4	4.2	**8**	3.4

Table 6. Food sources predominance in the foodscape

Categories	Subcategories	Neighbourhood		Buffer		Total	
		N	%	N	%	N	%
Entertainment	Amusements	3	2.1	0	0.0	3	1.3
	Snooker/pool clubs	1	0.7	0	0.0	**1**	0.4
	Bowling	2	1.4	1	1.1	3	1.3
	Sport related	0	0.0	1	1.1	1	0.4
	Cinema	1	0.7	0	0.0	1	0.4
	Subtotal	7	4.9	2	2.1	**9**	3.8
Health and leisure	Leisure centre	0	0.0	1	1.1	1	0.4
	Subtotal	0	0.0	1	1.1	**1**	0.4
Baker	Baker	0	0.0	1	1.1	1	0.4
	Subtotal	0	0.0	1	1.1	**1**	0.4
	Total	143	100.0	95	100.0	**238**	100.0

6.3 – Proximity of the food sources

The mean walkable distance from the centroid of the neighbourhood to food sources was 0.94 kilometre (km). The range of mean walkable distance of the different type of food sources varied between 0.43 and 1.84 km. Table 7 shows that on average, the nearest outlets by walking are the takeaway cafes situated at 0.44 km from the centre. Vending machines and entertainment –related food sources, were located to 0.64 and 0.75 km of distance respectively. The majority of the categories were situated in average distance in a range from 0.8 to 1.1 km.

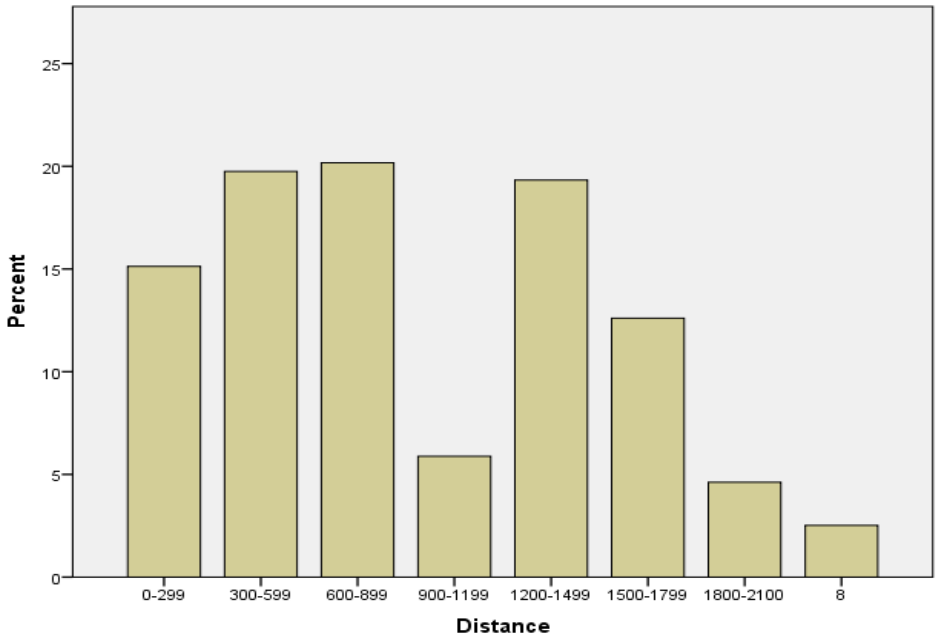
Table 7. Walkable mean distance by food sources category

Categories	n	Mean distance (km)
Take away and fast food	42	1.01
Convenience	38	0.95
Specialist	25	0.80
Restaurant, pub & hotel restaurant	24	0.97
Closed/Private food outlets	19	1.08
Mobile food vendors	18	0.95
Sit in café/coffee, specialist sandwich shop	16	0.99
Non-food stores	16	0.90
Pub no food	13	1.02
Entertainment	9	0.75
Supermarkets	8	0.9
Take away café/coffee, specialist and sandwich shop	5	0.43
Vending machines	2	0.65
Health and leisure	1	1.29
Baker	1	1.84

This is the case of the specialist outlets (0.8 km), supermarkets (0.8 km), non-food stores (0.9 km), convenience (0.9 km), mobile food vendors (0.95 km), restaurants (0.97 km), sit-in cafes (0.99 km), takeaway and fast food (1.01 km), pubs without food (1.02 km) and closed/private food outlets (1.09 km). The furthest categories with just one outlet each other, were health and leisure (1.28 km), and baker (1.84 km), which were located in the buffer zone.

To visually account for the spread of food sources across distance categories, the foodscape was divided in eight walkable distances categories every 300 meters (m). The number and distribution of food sources across the distance categories are shown in Figure 13. The major frequency was in the first four categories (n= 145) rather than the last four categories (n=93). The distance categories 300-600 (n=47) meters and 600 – 900 meters (n= 48) within the neighbourhood and the category 1200 -1500 meters within the buffer (n=46) have the major concentration of food sources within the foodscape. Categories 900-1200 meters (n=14), 1800-2100 (n=11) and over 2100 (n=6) have much fewer.

Figure 13 Frequency of food sources across eight distance categories within the foodscape



The Kolmogorov- Smirnov test confirmed the differences in the distribution of food sources across the eight walkable distance categories were statistically significant (p=0.0001). Furthermore, the Chi-square test suggested there are significance differences in the distribution of food sources across the distance categories between the neighbourhood and the buffer (p=0.001).

The shortest path was calculated to obtain the walkable distance in kilometres from the furthest residential points to the five food sources concentration points, as appears in Table 8.

Table 8. Walkable distances from further away residential points to food sources concentration hubs

Points of reference	Forge Shopping Centre (km)	The Hub (km)	Springfield Road (km)	Tollcross Road (km)	Shettleston Road (km)
North-eastern	1.39	1.46	1.50	0.50	1.50
South-western	1.35	0.72	0.35	2.20	1.38
South-eastern	1.97	1.34	0.96	1.85	2.46
South	1.88	1.25	0.83	2.34	2.07

The results show that the walkable distance to reach the Forge shopping centre and the hub in Gallowgate from the four residential boundaries points exceeds one kilometre in almost all the calculations. The south-eastern and south points were greater than two kilometres. To reach the food sources in Springfield road (within the neighbourhood and next to the Celtic Park stadium), the distances are shorter from the south, south-eastern and south-western points. However, this distance is higher from north-eastern point, which is located to 1.5 km from the concentration point. The distance from food sources hubs located in Tollcross and Shettleston to the residential points overpasses 1.5 km in both cases, reaching almost 2.5 km to walk from Shettleston, in the case of the south-eastern point. Only from the north-eastern point to Tollcross road the walkable distance achieved 0.5 km.

6.4 – Density of the food sources

The density of food sources into the neighbourhood reached 91.9 per km², whereas in the buffer density was only 14.9 per km² and in the foodscape was 30.1 per km². The food sources density per category is displayed in Table 9.

Table 9. Food sources densities by category in the neighbourhood, the buffer and the foodscape

Categories	Neighbourhood	Buffer	Foodscape
Take away and fast food	13.5	3.3	5.3
Convenience	13.5	2.7	4.8
Specialist	12.2	0.9	3.2
Mobile food vendors	10.9	0.2	2.3
Sit- in cafes and sandwich shops	6.4	1.1	2.2
Closed/Private food outlets	6.4	1.4	2.4
Non-food stores	5.8	1.1	2.0
Restaurant, pub & hotel restaurant	5.1	0.9	1.8
Entertainment	4.5	0.3	1.1
Pubs	3.9	1.1	1.6
Takeaway cafes	3.2	----	0.6
Supermarkets	2.6	0.6	1.1
Vending machines	1.3	----	1.3
Health and leisure	----	0.2	0.1
Baker	----	0.2	0.1

The densest group of outlets in the neighbourhood and the foodscape were takeaways and fast food outlets and the convenience stores in both areas, the neighbourhood (13.5 outlets/km² each one) and the foodscape (5.3 and 4.8 outlets/km²). They are followed by the specialist outlets, which also count a higher density in the neighbourhood (12.2 outlets/km²), and in the foodscape (3.2 outlets/km²). The fourth densest category were mobile food vendors, with a presence of 10.9 vans/km² in the neighbourhood and 2.3 vans/km² in the foodscape.

Sit- in cafes and closed/private food outlets showed a lower concentration within the neighbourhood (6.4 outlets/km²) in both cases and in the whole foodscape (2.2 and 2.4 outlets/km² respectively). Non-food stores and restaurants, pubs and hotel restaurants categories were concentrated in a lower proportion in the neighbourhood (5.8 and 5.1 outlets/km²) and the foodscape (2.8 and 2.1 outlets/km²).

Entertainment- related outlets had a lower density within Whitewood (4.5 outlets/km²) and their presence within the foodscape was minimal (1.1 outlets/km²). With regard to pubs which did not sell food the concentration was higher in the neighbourhood (3.9 outlets/km²), as well as the case for take away cafés (3.2 outlets/km²) and supermarkets (2.6 outlets/km²). The lowest density was reached by two categories which were only present in the buffer: health and leisure food related outlets (0.1 outlet/km²) and bakery (outlet/km²).

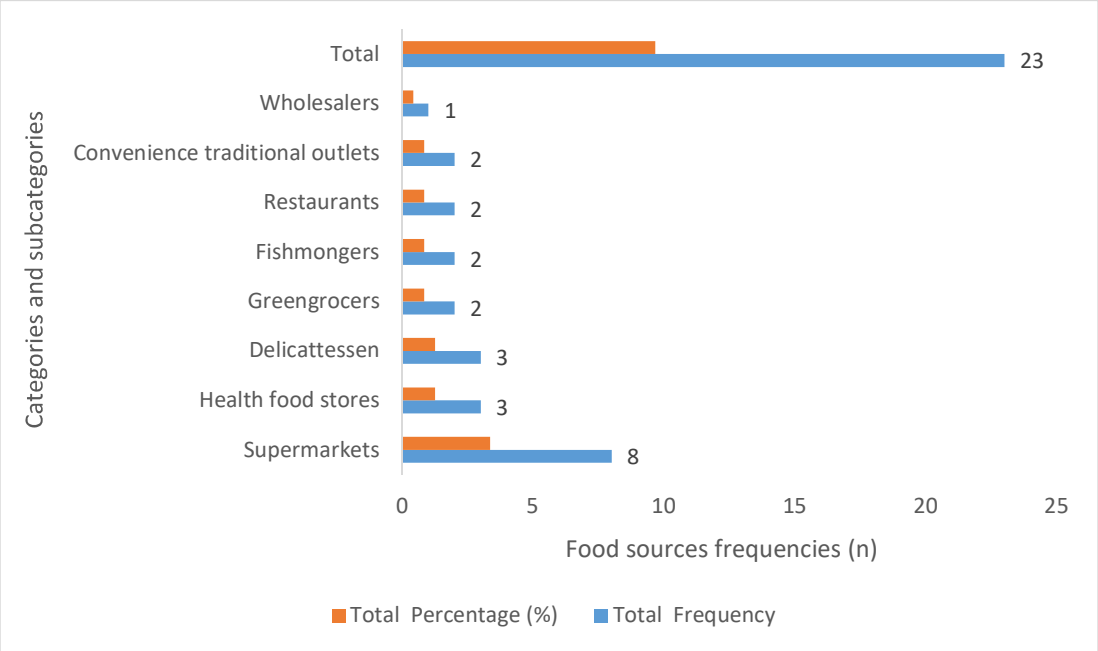
A Wilcoxon test showed that there is a significant difference between the densities across the categories in both the neighbourhood and the buffer ($p=0.05$).

6.5 – Comparison of healthier and less healthy food sources

6.5.1 Healthier and less healthy food sources predominance

As can be seen in Figure 14, 23 outlets classified as healthier food sources represent 9.7% of the foodscape. The most predominant were supermarkets (3.4%; n=8), followed by health food stores (1.3%; n=3) and delicatessen outlets (1.3%; n=3). With lower representation were greengrocers (0.8%; n=2), fishmongers (0.8%; n=2), traditional convenience stores (0.8%; n=2) and one restaurant (0.8%; n=2). There was only one wholesalers store (0.4%; n=1).

Figure 14 Healthier food sources categories and subcategories

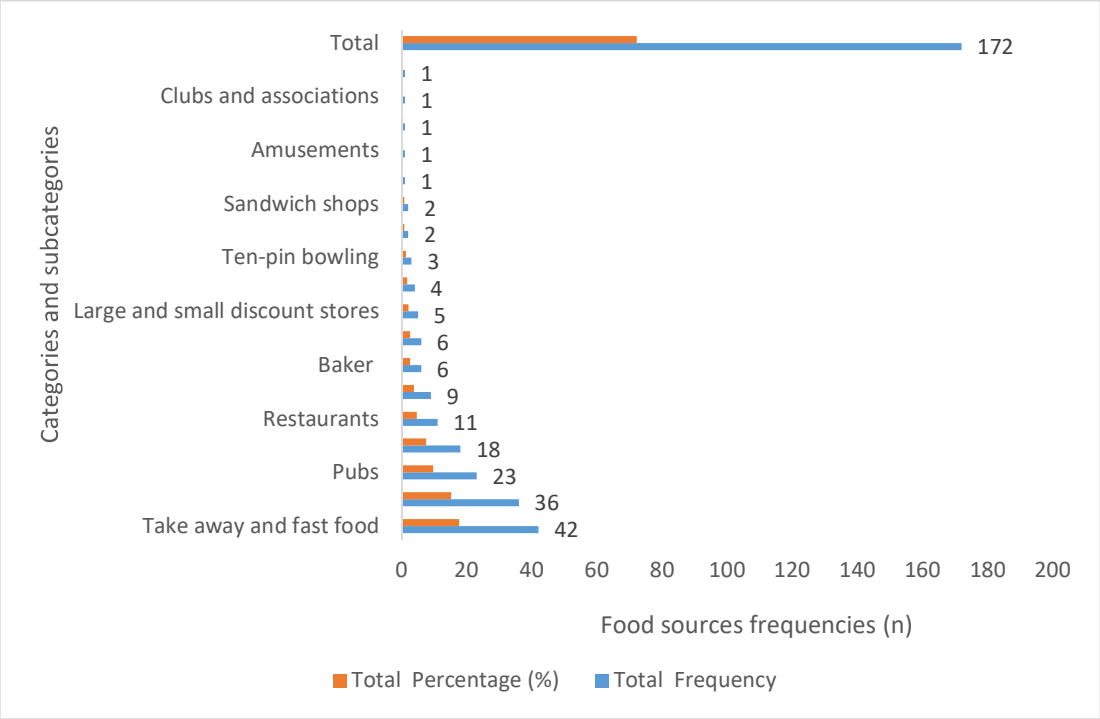


As can be seen in Figure 15, 172 outlets were classified as less healthy food sources, which represents 72.2% of the foodscape.

The most predominant were the “take away and fast food” places (17.6%; n=42), followed by the convenience stores (15.1%; n=36). The categories pubs (9.7%; n=23) and mobile food vendors (7.5%; n=18) also showed a high predominance over the remaining categories. Restaurants (4.6%; n=11) and “greasy spoon” type of cafes (3.8%; n=9) represented a lower proportion of the food sources, while the rest of categories were less predominant. This is the

case for butchers (2.5%; n=6), bakers (2.5%; n=6) and discount stores (2.1%; n=5), candy/sweet/chocolate shops (1.7%; n=4) and ten-pin bowling categories (1.3%; n=3).

Figure 15 Less healthy food sources categories and subcategories



Finally, categories such as vending machines (0.8%; n=2), sandwich shops (0.8%; n=2), club and associations (0.4%; n=1), cinema (0.4%; n=1), amusements (0.4%; n=1), sport-related café (0.4%; n=1) and gift shops (0.4%; n=1), represent less than 1% of the food exposure e.

The modified Retail Food Environment Index (mRFEI) showed that 11.8 out of 100 food sources were likely to offer healthier foods.

6.5.2 Healthier and less healthy food sources proximity

The mean walkable distance of healthier food sources was 0.93 km and of less healthy food sources was 0.94 km.

Regarding the distribution of food sources across the eight distance categories, as can be seen in Table 10, there are over 3 healthier outlets in the first three categories. The major number of healthier food sources was concentrated in 1200 – 1500 m category (n=8), whereas the categories 900 – 1199 m and 1800 – 2100 m did not have any store.

The majority of less healthy food outlets are distributed in the categories 300 – 600 m (n=39), 600 – 900 m (n=39) in the neighbourhood and 1200 – 1500 (n=36) within the buffer. The lowest number (n=12) was concentrated in the 1800 – 2100 m category, followed by the 900 – 1199 m category (n=15).

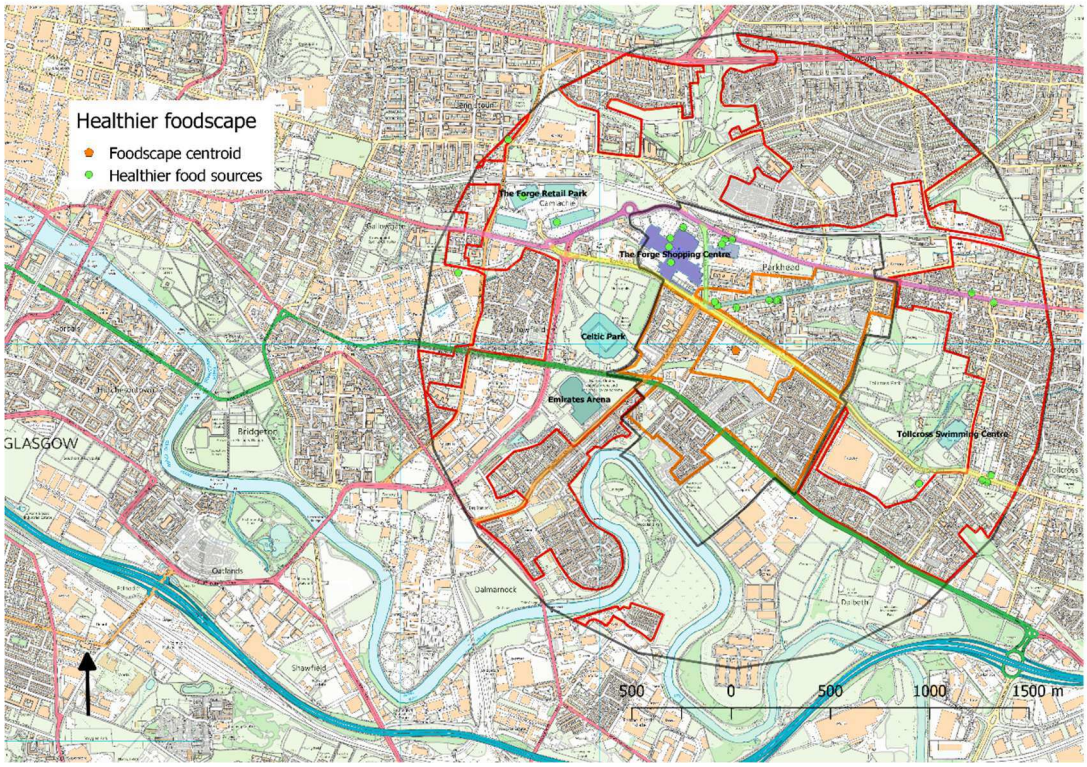
Table 10. Frequency of healthy and less healthy food sources by distance categories across the foodscape

Location	Distance (m)	Healthier Food sources	Less healthy food sources	Total food sources
Neighbourhood	0 – 300	3	25	28
	300 – 599	4	35	39
	600 – 899	6	33	39
	900 – 1199	0	15	15
Buffer	1200 – 1500	8	31	36
	1500 – 1799	2	21	23
	1800 – 2100	0	12	12
Total		23	172	195

The Chi- square test confirmed that healthy and less healthy food sources do not follow similar distribution across distance categories (p= 0.036). There is not enough data to support other hypothesis.

Figure 16 shows the healthier food map. According to the findings, 39.1% (n=9) of the healthier food sources were located within the Forge Complex, 26% (n=6) in the hub of the commerce and services, 8.6% (n=2) in the northeast area in Shettleston road and 17.3% (n=4) in Tollcross road. Only 8.6% (n=2) outlets were located outside these areas in the northwest edge of the buffer.

Figure 16. Healthier food sources map

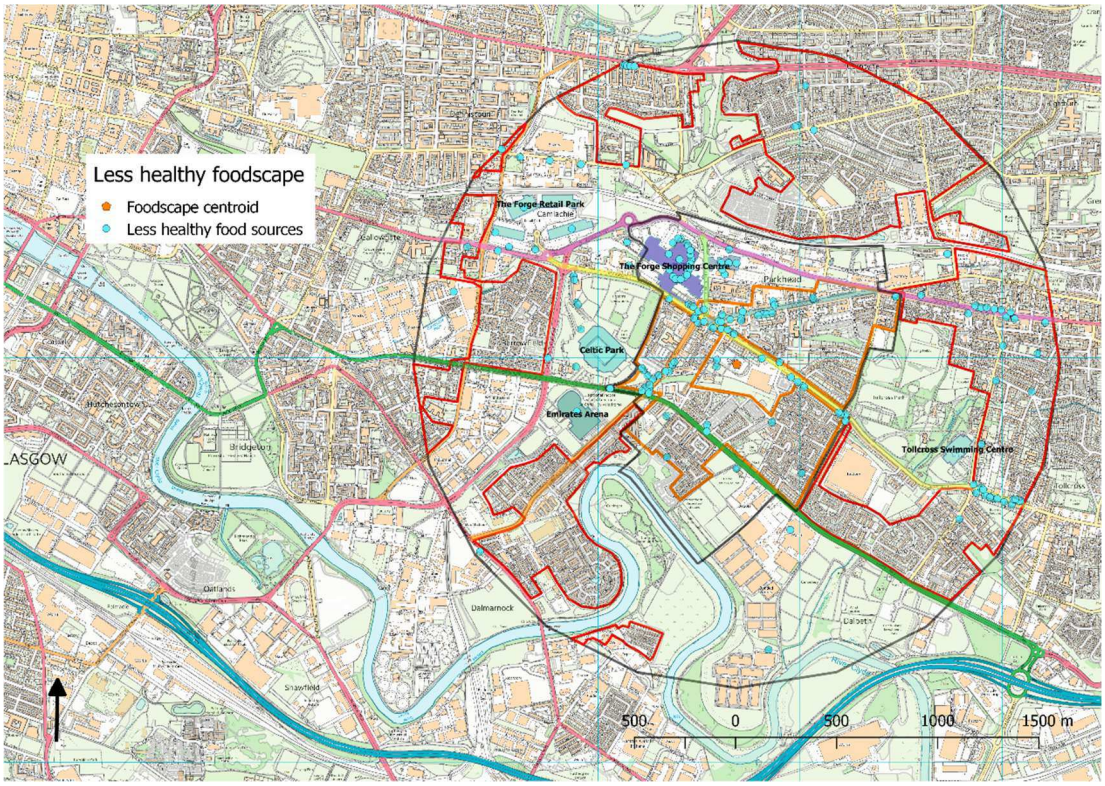


The walkable distances from the four distal residential area points to healthier food sources are similar to the general food sources calculations (note: see section 6.3 Table 8. This is because only with the exception of Springfield road there are no healthier food sources in that concentration point.

Figure 17 displays the less healthy outlets map. According to the findings, 19.7% were located within the Forge Complex (n=34), 17.4% in the hub of the commerce and services (n=30) and 8.7% in the intersection of Springfield Road with Gallowgate (n=15). In the northeast area, 8.7% were located in Shettleston road (n=15) and 10.4% in Tollcross road (n=18). These urban hubs

contain 65.1% (n=112) of the less heathy exposure (65.1%). The other 22.6% (n=39) outlets were located nearby and 13.1% within (n=21) residential areas, representing 34.9% of this type of food exposure.

Figure 17. Less healthy food sources map



The walkable distances from the four distal residential points to the less healthy food sources are similar (note: see section 6.3, Table 7). There was only one food outlet, located in Dalmarnock factories' area at the bottom of the foodscape, which is not considered close to the residential areas. Walkable distance from that outlet to the south residential point is 1.74 km and is 0.9 km from the south-east residential point.

6.5.3 Healthier and less healthy food sources density

The density of healthier food sources in the neighbourhood was 8.4 outlets/km², in the buffer was 1.6 outlets/km² and the foodscape 2.9 outlets/km². In the case of less healthy food sources, the density in the neighbourhood was 68.1 outlets/km², in the buffer was 10.4 outlets/km² and the foodscape 21.7 outlets/km².

Table 11.Density of healthier food sources in the foodscape

Healthier food sources	Neighbourhood	Buffer	Foodscape
Greengrocers	1.3	0	0.3
Fishmongers	0.6	0.2	0.3
Health food stores	1.9	0	0.4
Supermarkets	2.6	0.6	1.0
Delicatessen	1.3	0.2	0.4
Wholesalers	0	0.1	0.1
Convenience outlets	0.6	0.1	0.6
Restaurant	0	0.3	0.2
Density	8.4	1.6	2.6
Average density	1.0	0.2	0.3

According to Table 11, the healthier food sources density was on average 1.04 outlets/km² while in the buffer and foodscape it was 0.2 and 0.3 food outlets/km². Regarding the healthier subcategories' densities, the densest in the neighbourhood were supermarkets (2.6 outlets/km²), greengrocers (1.3 outlets/km²) and delicatessen (1.3 outlets/km²) while two types were not present in the area: wholesalers and restaurant with healthier options.

In the buffer zone, the densest type were supermarkets (0.6 outlets/km²) other categories did not exceed 0.3 outlets/km². Two categories were not present in the buffer: greengrocers and health food stores. In the foodscape, the densest type of outlets were the supermarkets (1.0 outlet/km²) while the rest did not exceed 0.6 outlets/km².

Table 12. Density of less healthy food sources in the foodscape

Less healthy food sources	Neighbourhood	Buffer	Foodscape
Take away and fast food	13.5	3.3	5.3
Convenience	12.9	2.5	4.6
Candy/sweet/chocolate shops	1.9	0.1	0.5
Greasy spoon type cafes	4.5	0.3	1.1
Sandwich shops	1.3	0	0.3
Clubs and associations	0.6	0	0.1
Ten-pin bowling	1.3	0.2	0.4
Sport-related pub/café	0.6	0.2	0.1
Cinema	0.6	0	0.1
Amusements	0.6	0	0.1
Vending machines	1.3	0	0.3
Large and small discount stores	1.9	0.3	0.6
Gift shops	0.6	0	0.1
Butcher	2.6	0.3	0.8
Baker	2.6	0.3	0.8
Pubs	6.4	2.0	2.9
Mobile food vendors	10.9	0.2	2.3
Density	68.1	10.4	21.7
Average Density	3.8	0.6	1.2

In the case of less healthy food sources, the average density in the neighbourhood was 68.1 outlets/km², while in the buffer this dropped to 10.4 outlets/km² and in the foodscape to 21.7 outlets/km² (Table 12). Takeaways and fast food (13.5 outlets/km²), convenience stores (12.9 outlets/km2) and mobile food vendors (10.9 outlets/km²) are the densest outlets within the neighbourhood, surpassing 10 stores per km². These are followed by pubs (6.4 outlets/km²) and “greasy spoon” type cafes (4.5 outlets/km²). Finally, in lower concentrations were butchers (2.6 outlets/km²), bakeries (2.6 outlets/km²), candy shops (1.9 outlets/km²), discount stores (1.9 outlets/km²), sandwich

shops (1.3 outlets/km²), ten pin bowling (1.3 outlets/km²) and vending machines (1.3 outlets/km²). Gift shops (0.6 outlets/km²), club and associations outlets (0.6 outlets/km²), sport –related cafes (0.6 outlets/km²), cinemas (0.6 outlets/km²) and amusements (0.6 outlets/km²) presented the lowest concentration.

Chapter 7 – Discussion: improvements of the study design and the methodology

This chapter analyses the methodological approach used in this study and compares it with other study methods, describing the strengths and limitations of the approach adopted.

The objectives of this chapter are:

- to analyse the research design and methodology and discuss those issues in comparison with the literature.
- to discuss the usefulness of foodscapes for policy makers and food environment researchers
- to describe the main strengths and limitations of the methodological design

The chapter is comprised of three sections:

section 1 discusses the development of the unique research design and methodology after examining the different designs within the relevant literature.

section 2 describes the strengths of the present study, and the advantages of the methodology design.

section 3 reported the main limitations of the type of design, methodology and conduction of the study.

7.1 – Producing a more representative local deprived foodscape: study design improvement

This study explored the food environment in a deprived neighbourhood through establishing a process of mapping a community food environment and the analysis of a foodscape. The information gathering combined a multidisciplinary approach, including GIS, nutritional epidemiology and public health fields. This research responds directly to key gaps in the literature

identified in the scoping review, where previous studies identified only a few characteristics of the community food environment within a deprived neighbourhood with its unique obesogenic characteristics. This evidence allowed me to prove my first and second hypotheses, which stated that foodscapes were designed to represent a small part of the food environment and the spatial analysis of their obesogenicity was poorly developed. Using GIS technology and GEO - Fern Guidelines recommendations (112), I was able to demonstrate the presence or absence of food sources related to deprivation, the healthier exposure, food deserts and food swamps. The combination of all those characteristics plus the visualization of different types of food sources distribution patterns makes this foodscape an original piece of evidence and a precedent for the literature. This also allowed me to test and prove my third hypothesis, which stated that using the correct methodology, Whitewood neighbourhood possesses an obesogenic food environment.

Methodology changes from previous published studies analysed in the scoping review are the following:

A more discreet, and of necessity, a smaller dense selection of the neighbourhood and definition of the study area based on the need to understand the intricate obesogenic exposures relative to peoples' daily lives.

Expansion of the community food environment exposure

Exhaustive data collection

Fieldwork and online validation

Classification improvement

Combine GIS measures assessment

A selected neighbourhood that contained all the marker points of deprivation including a) low educational level, b) low health profile, c) high commercial activity, d) high rates of obesity and e) densely populated.

The neighbourhood chosen allowed this methodology to be fully applied. Whitewood is an emblematic Glaswegian neighbourhood, classified in the highest level of deprivation and exhibiting all of the above points (117,119). It is a representative area and part of the several deprived neighbourhoods suffering from the “Glasgow effect” (116). One limitation of the study is that I was unable to involve a comparison neighbourhood. However, within the confines of this PhD study, and with the recognised need to provide a deep intense examination rather than a broad shallow examination the interconnectivity of food source exposures, I committed to only one neighbourhood analysis

A neighbourhood was an area that was defined within the most accurate limits. I have demonstrated in this study the challenges of accurately defining the boundaries of a neighbourhood. Previous research has used administrative boundaries to represent the community food environment (49,55,58,67,68,72,80,84). The use of these fixed boundaries such as census tracks and zip code zones, has been accepted by the research community using spatial analysis methods, as acceptable proxies of neighbourhoods (38,112,122) . In most of the cases, the resources available to conduct these types of studies are limited to conduct indepth interviews with the residents and there is a lack of other available boundaries to represent the neighbourhoods. However, Mikkelsen and Cobb et al. among other authors, have recognised these arbitrary boundaries do not necessarily reflect a more socially recognized neighbourhood among the residents and therefore, their local food shopping area (17,49). After analysing the different available boundaries, searching across a number of databases for boundary data points, I designed my study based on the community council boundaries, which were the only fixed delimitation that reflected the Whitewood consensual borders and incorporated households with similar socioeconomic circumstances,

historical points of interests, typical streets and residential areas (123,124). This allowing me to conduct an analysis using consensual boundaries.

A 1-mile buffer area to explore the peripheral food sources beyond the neighbourhood boundaries was also included. The expansion of the food shopping area, reflecting the daily pattern of activities with residents crossing local boundaries to purchase food and as well as residents in different parts of the neighbourhood holding different perspectives on what was their "neighbourhood". The buffer also incorporated the Celtic Park stadium and the Forge Retail Park, which had been located outside the demarcation lines of Whitewood, yet were regarded by the Council and the residents as an essential part of the neighbourhood. The Celtic Park stadium was considered an iconic point of historical interest in the neighbourhood. The dimensions of the buffer size were selected based on a seminal research study conducted in the UK by Smith et al., who found that 95% of food purchases were made at 1-mile walkable distance from the customer's household address (125). The use of a buffer zone is missing from many research studies; an omission, which has added to the challenge of comparing study findings (58–60,62,84).

Expansion of community food environment exposure, including an increase in the number of food sources and the type of food sources.

The number of food sources used in previous studies has been relatively small; a fact that has been recognised as a research limitation (37,49). These limitations have been because of the size of the datasets, which require more time for validation and classification. Since the majority of the studies set out to explore the relationship of the community food environments and obesity, the study focus was on the most representative healthy and less healthy categories and not in the general food environment description. For this study, I adapted other traditional and non-traditional food sources from the classification system published in 2010 by Lake et al. (113). This development extended the search, enabled a more accurate capture of food sources types as well as facilitating a clearer confirmation of the two types of scenarios: food swamps and food deserts.

Expansion of the data sources. Other studies have used only one official list for food sources, commonly the Local Council or government official database (58,62,73,75,86) According to authors' discussions, the main reason that only one dataset was used in the majority of studies was due to time and economic resource constraints. Lake et al., Burgoine et al., Cobb et al. and Geo- FERN guidelines have reported that the use of a single database was a limitation leading to incomplete or outdated information (104,112,113). To respond to this identified limitation I built a food sources database, informed by a combination of six different public and private directories and websites. The access to each data source was challenging as each data source used different filing systems. Other limitations included: i) duplicates, ii) missing data, iii) confused information (using in some occasions commercial names instead of the fantasy name) and iv) complicated, time-consuming paperwork to obtain access permission. However, after a cleaning process, the combination of multiple data allowed me to capture more food sources and to improve: a) the reliability, b) completeness and c) validity of the collected data. While the Glasgow Council's food premises database achieved a high sensitivity, which meant it was highly accurate and precise, containing 90% of the food outlets confirmed during the fieldwork, the updated database I constructed allowed me to include a number of additional entries.

Onsite and **online validation**. Checking and authenticating database accuracy is good practice. I conducted an audit in Whitewood to corroborate food outlets data and obtain more information to describe the neighbourhood and community food environment features, as well as facilitate a later classification. I completed the validation using online websites and the AddressBase® Plus database to confirm missing data. Few previous studies included this critical step, thereby negatively affecting the reliability and accuracy of their data findings. The validation exercise enabled a refinement of the database by: i) deleting old records, ii) including new outlets and iii) changing data on others. Direct observation provided insights into the nutritional and informational food environments and enabled the re-

categorisation of food sources with additional information, something that has not been included in previous studies (112,113).

Before and after the validation process, each food source was classified, using 15 categories and 104 subcategories proposed by Lake et al. in their 15-point classification tool (113). This **classification system** is specifically designed within the context of the UK to identify a wide range of food establishment categories commonly present in the community food environment (113). It uses a clear set of constructs to define each category, including many quality definitions and is sensitive to detect “food swamps” or unhealthy community food environments and peripheral categories, such as stores where the primary products on sale are not foodstuffs (113). The system also includes non-traditional categories such as food banks and street vendors, which are relevant to deprived scenarios (113).

Few studies divided food outlets into subcategories choosing to explore one, or a few types of food outlets and categories, only (62,67). Yet the classification of food sources into a broad range of categories and subcategories brings considerable rich data that adds depth to the analysis and description of foodscapes.

The same classification system allowed the categorisation into healthier and less healthy groups. Both categories include a higher number of food outlet types than has been previously reported in the literature, covering a higher proportion of each type.

To enhance the community food environment assessment, I used **a set of GIS measures** to evaluate the different variables associated with the foodscape. These included: a) prevalence, b) proximity to and c) density of general food sources, as well as healthy and less healthy groups. By utilising all measures, plus an additional food environment index, the study was able to report on all the variables of this sub-type of environment: i) number, ii) type and iii) location. Previous studies have tended to only use a single measure or combination of two measures, thereby only partially analysing a community food environment

(55–60,62–64,66). This novel, comprehensive combination of measures has enabled me to assess accessibility and indirectly, availability of the food sources overall, as well as categorising those sources into healthy and less healthy types.

The outcome of this study has been a detailed and representative map of the Whitewood neighbourhood, which visualises the whole food exposure and describes the most relevant general and obesogenic features of a deprived neighbourhood. Every urban environment has unique spatial characteristics that require to be considered for future policies and health interventions (17,37,122). A “snapshot” of the community food environment facilitates the visualisation of the food sources quality, distribution and accessibility that are particular for each neighbourhood, in a clear and didactic way. According to Mikkelsen, foodscapes are a valuable tool “to understand how people, spaces and food interact and how this interaction influences our food behaviour” (17). This interaction must also be mapped over time, considering the heterogeneous distribution of the different food sources and the dynamic changing nature of the community food environments. Every neighbourhood is different. There will always be different distribution patterns of the food sources and not all the residential areas (17,38,122).

In the case of Whitewood, an excellent example of the differential exposure can be seen in the residential areas closer to The Forge retail complex and shopping centre. They have greater access to all types of food sources in comparison with the households located at the edge of the neighbourhood, adjacent to Dalmarnock. Food exposure also changes with the constant opening and closure of outlets (41,113). In the most disadvantaged areas, such as Whitewood, small businesses open, change names and/or types of food and continuously close down due to bankruptcy or other economic constraints. I observed this situation during my fieldwork after talking *extra-officially* with residents and outlet managers.

Foodscapes are premised to become increasingly valuable for policymakers, researchers, local business, owners and for all the people involved in the

analysis of the community food environment (17,113,122). They might be a useful visualisation tool to establish a long-term obesity prevention plan to improve both neighbourhoods and whole cities. Even if the foodscapes are simplified and adapted to the local resources, they can help monitor the levels of less healthy food exposure within urban areas, as well as comparing those levels over time. In this way, local authorities can: a) introduce food environment policies, b) support planning decisions and c) evaluate their implementation (note: the discussion of different types of food environments policies is developed in section 7.4) (17,113). One excellent initiative that might be replicable by local authorities was developed by the Centre of Diet and Activity Research (CEDAR) of the University of Cambridge in 2018 (155). They created the Food Environment Assessment Tool (FEAT) that permits some cities and some neighbourhood foodscapes in England, Wales and Scotland to be seen for the purpose of monitoring access to food sources (155). FEAT assesses by the moment: i) restaurants, ii) cafes, iii) takeaways, iv) supermarkets, v) convenience stores and vi) speciality stores (155). Although it does not contain all the available food sources, the tool shows the most associated food sources to obesity.

The Whitewood foodscape shows all the places where people can encounter and eat food and displays the food quality around and within residential areas. As the example mentioned above, this data is highly relevant to define the obesogenicity level of the neighbourhood and to any potential upcoming action plans. Such plans must also include other elements of the obesogenic environments, such as physical activity level and space to practice exercise and spend active leisure time (5,8,80).

Furthermore, food sources are part of a complex built environment that exist in a range of contexts, including deprived circumstances, which can provide extra information, i.e. outlets used as a cover for other types of activities, which may be illegal or antisocial. In areas of deprivation, some types of food sources appeared to function as a “façade” for criminal enterprises such as drug dealing, or for illegal gambling. During my fieldwork, I observed some drug

transactions in front of particularly outlets (not identified in this thesis or protection reasons), It was unclear whether there was consent, or indeed collaboration from the outlet owner. Additionally in the shopping complex, an entertainment outlet for children contained a second room with a mini-casino area for parents, covered by darker windows and with restricted access for the public. Some of the public houses selling only alcohol, with darkened windows and duty guards, indicated additional activity; a sensitive issue, which is beyond the remit of this study.

Detailed foodscapes shine a lens on the multiple determinants of ill health. This community food environment "photo" gives indicators of the challenges and opportunities for understanding and changing behaviours. It also points to the need for a depth in exploration. Local Council authorities have taken council wide decisions based on desk based data of a few neighbourhood case studies but as this foodscape shows the realities of the foodscape are likely to be different from that produced from a single data sources, and will differ within neighbourhoods, even if they are contiguous. It is vital to investigate in an in-depth manner each critical neighbourhood where there are clusters of deprivation indicators, given the unique features that influence and determine residents' food behaviour.

7.2 – Study strengths

The unique research design of this study benefitted from the recommendations made by authors, elicited through a comprehensive literature and scoping review, and several suggestions made by experts in the field of food environments

As I described in the previous section, the multi-staged design allowed me to obtain a more representative foodscape and to describe a vast number of food sources - representing the complete neighbourhood physical food exposure. Through the new universe of outlets, I could picture the presence of more types of food sources that had been invisible in previous studies, showing the real exposure and a complete snapshot of the obesogenic landscape. I also

analysed the absence and potential impact of the lack of food outlets in the residents' diet. Despite unique neighbourhood characteristics, according to the evidence discussed in chapters 3 and 4, there are common factors that presumably are present in deprived neighbourhoods that will allow policy makers to extrapolate and generalise this neighbourhood food environments features and analysis to settings with similar contexts. Just to mention some of these factors, there are a high presence of food swamps and food deserts in poor neighbourhoods, not only in the UK but also in Australia and North American countries with high obesity rates. These type of neighbourhoods may amplify the deprivation effect that poor living conditions (including an obesogenic food environment) have over vulnerable population health status.

The report of a less healthy food basket was another valuable finding of this study. As will be described in the following chapter, although the measurement of the consumer food environment was not part of the aim, the identification of a set of high-energy dense foods will be a helpful antecedent for local authorities. These outcomes are unique, as no authors have analysed the impact of absent supermarkets and healthier food sources, as they examined food deserts.

This study contributes updated evidence on the topic of, and confirms the presence of obesogenic environments in a Glaswegian neighbourhood. Furthermore, the study provides data to compare and discuss the findings with other national and international studies, as the obesogenic environment is also common in other parts of the world with similar characteristics.

It also contributes to the sensitivity analysis of the local Council food premises dataset validity, which achieved over 90% of accuracy and represents a reliable data source for other researchers and local authorities that would like to use this dataset with or without the option of direct validation.

This study, the first in Scotland and probably, one of the few globally to describe a complete community food environment and its potential obesogenic influence will be a precedent for future research in the area and contribute to

other researchers to design their studies. My findings could support constructive changes in future local policies and help to characterise better the food environments and its obesogenic elements indistinctly the region of the world.

7.3 – Study limitations

The first limitation of this study is the cross-sectional design, which only measured the exposure (13,49). As I described in the methodology, the study incorporated measures assessed only once, restricting the possibility to analyse only one snapshot of the community food environment. As there was not the possibility to collect data on obesity among Whitewood residents, I did not have the opportunity to determine how the exposure is associated with the outcome.

Given its time and resource intensity perhaps the replication of a study with all the same characteristics will not be feasible for Councils to use as a frequent food environment surveillance tool. However, its adaptation to local context and resources might be possible.

Neighbourhood spatial delimitation also presented limitations. Despite using the more consensual arbitrary boundaries, these did not include essential points of interests that historically have been part of Parkhead, as the Celtic Park Stadium and the Forge Retail Park. Therefore although the limits were consensual with the residents, they might not represent their residential food shopping area, which might produce an imprecise measurement exposure.

Online validation has limitations. The most-reported limitations are lack of updated data (websites and google street views photos and menus information) which could result in sample errors such as the inclusion of stores that appear in google maps or websites as open but which are permanently closed. Other limitations include the classification bias at categorising an outlet in the wrong category by using data from out of date menus

Assuming that the type of food sources represents the in-store availability can also lead to bias since the real availability might differ. A clear example of this assumption has been reported with supermarkets; many studies have used as a proxy of healthy food sources. Studies measuring the consumer food environment have found that depending on the location and the size of supermarkets, the same chain can vary enormously in their in-store content, varying the number of healthy option, prices and promotions. This assumption opens the debate about whether all the supermarkets should be classified as healthy sources. I took the recommendations of previous reports to define the supermarket group as “healthier”. However, the mixed exposure, meant that they did not qualify to be described as a “healthy food source”.

The last limitation is an important assumption that people in Whitewood are shopping for food within Whitewood. Although the ethnographic evidence pointed residents buying their essential food within their neighbourhoods on a daily basis, this inference could not be confirmed in the study.

Chapter 8 – Discussion: deprived and obesogenic community food environments

The chapter presents an analysis of the main findings, and a discursive comparison with the existing literature.

The objective of the chapter is:

- To analyse the results in concordance with the proposed research aim and objectives

The chapter is comprised of two sections.

section 1 describes the general features of the deprived community food environment in Whitewood

section 2 explains the general and obesogenic characteristics found in the foodscape and compares them with findings reported in national and international literature.

8.1 – Geography of the deprived community food environment in Whitewood

Spatial disparities

The second thesis objective is to describe the general features of a deprived community food environment. This description is a foundation for understanding the context in which the food choices are made. During the fieldwork, I identified that several different types of businesses that are affordable to members of a low income population were present in Whitewood. Examples of these include low cost rented properties, discounted clothing and furniture outlets, tattoo shops, cash-advance services, coin laundry services and charity shops. Many of these outlets are located within the Forge Retail Complex as well as, and within the main streets. Other signs of poverty were also present in the neighbourhood. Some examples included second-hand

assets, as well as metal curtains and bars to protect shops from robberies. During my audits, I also observed littered and dirty streets with garbage overflowing in rubbish bins; homeless people seated strategically in busy intersections asking for money; and derelict public infrastructure such as: benches, roads and some vandalised bus stops. These structures and businesses are evidence of the socio-spatial disparities that exist in our society, where low-income consumers are exposed to poor li conditions, unsafe spaces, and high levels of pollution (156). As I discussed in chapter 3, this prolonged exposure to an unhealthy environment negatively impacts on residents' life expectancy, health outcomes and general quality of life.

General Foodscape Features

Regarding food-related exposure - as visualised in the foodscape map (Figure 12) section 6.1 - I found 238 food sources in total, distributed across 15 main categories and 39 of 77 available subcategories. Food sources are more predominant in some categories than others, a difference which is statistically significant within the neighbourhood and the foodscape. As reported in the scoping review, the most predominant food sources category within obesogenic foodscapes were those less healthy food sources, namely fast food outlets and takeaways, followed by convenience stores, representing 17.6%. The categories of restaurants & pubs and specialist stores, sit-in cafes and sandwich shops, closed & private food outlets, mobile food vendors and non-food stores represented 6% to 10% of the foodscape outlets. Whilst other categories such as entertainment, supermarkets, and take away cafes only represent between 3.8% and 2.1% of the foodscape.

General density within the foodscape reached 30.1 outlets/km² while within the neighbourhood reached 90.1 outlets/km². Following a similar trend of predominance, the densest type of food sources was again within Whitewood and the buffer, fast food outlets and takeaways (5.3 outlets/km²), and convenience stores (4.8 outlets/km²), specialist stores (3.1 outlets/km²). In lower proportion appeared mobile food vendors (2 outlets/km²), sit-in cafes and sandwich shops and closed and private food outlets (2.1 outlets/km² each one)

and non-food stores (2.0 outlets/km²). Supermarkets (1.0 outlets/km²) and take away cafes (0.6 outlets/km²) were among the lowest densities.

Though percentages and densities of food sources by type can be considered low, altogether, they show a high neighbourhood availability of different businesses and sources offering food, indicating that residents have multiple choices to purchase food locally. Food is everywhere and is easily available in many establishments selling food either primarily or secondarily to other products or activities, e.g. a) those related to adults' and children's entertainment, b) social gathering, c) sports events and d) retail shopping areas. This variety includes traditional outlets such as convenience stores and non-traditional food sources as food banks or community centres. Bodor et al., Oreskovic et al. Rundle et al. and Zick et al. in the US and Le in Canada, have measured between five and ten types of outlets, highlighting a much greater diversity than other studies (64,66,67,73,91). Black also incorporated food banks in the list of outlets (71). However, none of the studies in the review of the literature provided an indepth look at the detail of each food outlet as this current study has sought to do.

Similar to other deprived environments, Whitewood has the presence of small and discount stores selling mostly processed and canned food at lower prices, located in the Forge complex (5,8). Although the range of food stores types is diverse and the number of outlets per area should represent a high availability of products and preparations, the real scenario shows that there is a marked trend to offer a **set of ready-made food at a low price, easy to collect or delivery at home**. The frequent consumption of these preparations is in line with evidence described by the Social Market Foundation and Burgoine et al. that confirmed a higher number of takeaways in deprived areas and also a significantly higher density in the poorest areas (100,104).

Even though it was not part of my objectives to measure the consumer food environment, I observed some of its features, with the intent of improving the food sources classification and to better describe the community food environment. It was particularly interesting to note that ready-made food was

focused on a set of simple, fast food meals and snacks that do not involve high culinary techniques or gourmet recipes. No matter whether the vendor was a full - service restaurant, a takeaway café or a mobile food vendor, the offers looked very similar. I will describe this availability in more detail in the next section. Significantly, this availability is different compared with more affluent areas, where at naked eye, there is a greater diversity of sit-in restaurants and cafes. Menus in more affluent areas tended to offer traditional or innovative slow-cooked preparations, thematic meals and more elaborated snacks (113).

Sit – in options are limited in part for the reduced space and precarious sanitary conditions and spatial infrastructure of the establishments. I observed these features frequently and, except for sizeable fast-food chain such as McDonald's, other outlets looked unfit for purpose and unappealing to those customers wondering whether to consume food on site. These sub-par outlets were poorly lit, dirty, with old-fashioned furniture or poorly decorated. Their ventilation systems were limited, so often there were strong unpleasant smells in the air. In contrast, in wealthier neighbourhoods, establishments are well maintained, are attractive and price competitive in order for businesses to hold on to their customers.

The mean distance for a person walking from the centroid to a food store was 0.94 km. This estimate should be carefully interpreted, considering the average expresses the central values of a set of data. In this case, it is considering a range of stores located between 0.43 km from the centroid to others located almost in the foodscape edge at 1.84 km. Thus, the measures are masking the different distances at the individual business type level. The same trend follows the majority of the mean walkable distance by food source type since almost every category has outlets nearer to the centre and in the buffer limits.

Regarding distribution patterns, Whitewood is a quarter of the size of the buffer area and contained over half of the food sources (60.1%). The proportion is concordant with the concentration of food sources across the eight walkable distance categories (four categories within the neighbourhood and four within

the buffer). The highest proportion of food outlets is concentrated within the first four categories in comparison with the remaining distance categories located in the buffer area. The difference in proportions was statistically significant ($p<0.0001$) and indicates that Whitewood' residents have access to a broader range of food sources within the neighbourhood. According to these findings, from Whitewood centroid every three blocks around, a resident or person walking for food shopping should have access to 48 food sources within a 5-minute walk. However, this calculation is assuming that concentration measured in a perimeter around the centroid is homogeneous. After observing the foodscape map, it is evident this distribution is not uniform and is focused on some specific point within the foodscape.

The analysis of the spread of food sources confirmed the later and showed the two Whitewood residential areas have a differential exposure between them, which can be seen in table 8. Although there are food sources distributed in multiple sites, the food sources were mostly concentrated in five points within the foodscape. Three points located in the Northwest area of Whitewood (The Forge Complex, the hub and Springfield Road) and two situated in the Northeastern side, at the end of the buffer (Tollcross Road and Shettleston Road).

To assess differential access, I analysed the walkable distances from the four distal points within the neighbourhood residential areas to the five concentration points. I found that the differences in distances were significant. Surprisingly, walkable distances within the neighbourhood were more extensive than I expected. From all distal points to reach, residents would walk between 1.35 km and 1.97 km to reach the Forge shopping area, which represented about 16 to 23 minutes walking to shop in that venue. In the case of the hub (intersection of Gallowgate, Westmuir Street and Duke Street), walking from the furthest points varied from 0.72 km to 1.5 km, representing between nearly 9 to 18 walking time. From Springfield road, the walkable distance varied from 0.35 to 1.5 km, which means 4 to 18 minutes on foot. As I expected, Tollcross and Shettleston Roads, showed longer walking

distances, which varied from 0.50 to 2.46 km. To walk such distances will require from six to thirty minutes. Unexpectedly, walking from the hub and Springfield Road are the shortest paths and the closest to households. The Forge shopping centre, as well as the surroundings, such as the Forge Market and the Retail Park, is not closer, as I appreciated on the map for distal points. People living near the south-eastern and southern distal points had to walk between 0.83 to 2.07 km, taking between 10 to 25 minutes.

Analysing proximity calculations, it is possible to observe that although the food source concentration was higher within Whitewood than the rest of the foodscape, the stores are distributed irregularly around its centroid. Some part of the neighbourhood contains clusters of outlets, and others have considerably lower availability and accessibility as it can be observed in the foodscape map (Figure 12) in the section 6.1. People living in the distal points have to walk more if they want to reach these most concentrated zones within the neighbourhood and the buffer in comparison with people living nearer these points. In contrast, only considering the presence and density of fast food, takeaways and convenience stores, visible in the foodscape map, it is possible to see they are present in more sites beyond these five points, so in reality increasing even more the availability and accessibility of these foods.

As discussed in the scoping review, the results from this analysis of primary data are consistent with what other authors as Laraia et al. and Morland et al. have reported (58,97). Though the distances are manageable to walk once or twice a week, for those who have no means of transport, the distances can discourage the daily purchase of basic foodstuff in these busy commercial points. This is concordant with Smith et al. findings, which showed that walking for daily living, such as accessing public transport, getting to work and domestic activity is the most popular physical activity across all SES (125). Walking for shopping, including food, was one of the most popular reasons to walk. Residents perceived neighbourhood areas, on average, represented only 0.56 – 0.73 km, which means approximately between 6 to 9 minutes by foot for their daily activities. Colabianchi described this as an "easy walking

distance" for older female adolescents that representing a 5 minute walk in a 0.75 km distance (157). However, Smith et al. also reported that 42% of participants' shopping took place beyond the neighbourhood's limits, reaching a maximum one walkable mile (125). Considering this, those walking from distal residential areas households to the three neighbourhood points of interest are achievable.

Although it is not possible to compare frequency as it was not assessed, Macintyre et al. found in Glasgow that people in poor neighbourhoods were more likely to buy daily groceries in convenience stores and small outlets near their homes; an exercise involving an easy walkable distance (158). Easy walking distance may play a role in the frequency of shopping (157,159). It is also possible that the residents' use of local shops might have also been influenced by: a) socio-cultural habits to buy in those establishments or b) the financial benefits of bulk–buying from large supermarkets.

Though there was a wide range of food outlets, other types of businesses and sources were absent, for example there were no public houses with sit down restaurant, or with a delivery or take away service option. These types of outlets need extensive infrastructure and also a client base who can pay for at least a two or three courses menu, which is often beyond the expenditure of those in poorer socioeconomic groups. I found neither specialist cafes, nor cafes/bakeries serving delicatessen foods, which again are outlets associated with more expensive gourmet products. Other similar categories such as organic food stores, fair trade stores, seasonal/farmers' markets, artisan food stores, wine merchant shops and dry goods were also absent. Although these types of stores offer mixed quality food, many of the products are healthier (5). Among these are a) vegetables and fruits from farmers' markets with organic choices, b) dried fruits, c) wholegrain bread and bakery products low in fat and sugar, d) organic foods which have better quality, e) types of cheese, f) organic dairy products g) healthier confectionery and bakery (e.g. low in fat and low in sugar pastries with dried fruits) and, h) products from other parts of the world (herbs, condiments), etc. Beyond fruits and vegetables, there is also a range

of products and preparations that could provide better quality of flavour or variety to the meals. Although there is no literature analysing the impact of the lack of these specific types of outlets in these areas of deprivation, it is possible to infer that a reduction in variety, which, in turn, decreases the food purchase choices, will negatively affect dietary diversity.

Some peripheral subcategories of outlets related to higher income population spaces were also absent (113). Examples of these include furniture-design stores, hardware stores, post offices and department stores. Additionally other subcategories relating to entertainment, such as theatres, comedy clubs, music venues, art galleries and library shops were missing (113). In the health and leisure field, also absent were health clubs, climbing centres and soft play establishments. Finally, within closed and private food sources, there were no function rooms, food suppliers, food distributors and caterers. These outlets are also related to higher income and by association a higher quality of life. In such a context people can afford to pay for leisure and entertainment activities or buy higher quality clothes and more expensive assets for their households. The lack of all these establishments plus services such as banks branches, ATMs and electricity companies offices, among others is associated with spatial inequalities that decrease the residents' quality of life and chances to spend their leisure time by getting involved in other activities (156).

Food banks and non-profit organisations

In contrast, in most economically disadvantaged urban areas some type of food sources are present that are not frequently present in wealthier zones. The most common examples of these are the aid and non-profit food sources: i) food banks, ii) charitable organisations and iii) religious organisations. My results have shown these non-traditional food sources are also present in Whitewood. Religious organisations frequently advertised free food after a service or after having attended an activity; community centres also offered free snacks as a part of many group activities. They offer a modest range of snacks and products that generally may be classified as high-energy food sources, increasing the availability of these type of foods in the area. Black et

al. in a study conducted in New York, did not find association between food banks and obesity, though identified their less healthy availability (71)

Two food banks were located in Whitewood. Food banks in Glasgow provide emergency food and other complimentary benefits (139). Emergency food might vary depending on the donations, as well as supermarket and wholesalers' prices (139). However, generally, emergency food includes baskets of non-perishable and in-date food, which is given to the recipients on a monthly basis (139). The basket might incorporate items such as: i) breakfast cereals, ii) tinned soups and stews, iii) pasta, rice and pasta sauce, iv) tinned meat and fish, v) tinned beans and vegetables, vi) tinned fruit, vii) condiments and herbs (salt, mayonnaise and pepper), viii) canola and olive oil, beef broth and stock, ix) chicken, x) vegetables and xi) canned fruit juice. There is little doubt that emergency food can, in the short-term, contribute to economically disadvantaged households. However, over the long-term the continued consumption of these products could contribute to an imbalanced diet, low in vitamins and minerals and high in sodium, fat and sugar (160). Many of the items are caloric and processed products, and there is little availability of fresh products (160).

The Salvation Army, one of the major charitable organisations in the UK, has a branch in my fieldwork area (Gallowgate Street) which offers soup, sandwiches and hot and cold beverages (coffee, tea, soft drinks) twice per week. Their mission is to provide a meal to prevent an individual from experiencing undernourishment, but there is no capacity to plan this contribution as part of a balanced diet for each recipient. Similar services are also given in the area by two (other) religious organisations and two community centres; all of them offering hot and cold beverages, sandwiches and cakes twice or three times per week. Although they are not giving out emergency food, these free snacks are highly caloric. Altogether these sources represent only 2.5% of the neighbourhood's food exposure; they contribute to increasing the recipients' weekly intake of calories and consequently, to their weight gain.

The British Heart Foundation advised beneficiaries of food banks to consume canned fruits and vegetables low in salt/sodium and sugar (161). However, as contents of these 'relief' baskets are dependent on donations; beneficiaries do not have the option to choose products. The study "A Nutritional Analysis of the Trussell Trust Emergency Food Parcel", conducted in 2018 reported that the 3-day food parcels in 5 food banks in London, often exceeded the nutrient requirements for: a) calories, b) protein, c) minerals, d) trace elements and e) vitamins (except for Vitamins D and E) (160). The products were high in sugar, salt, and low in vitamin D and E, which are essential vitamins to keep bone mineral density and protect against cardiovascular diseases. I did not include these sources within the 'less healthy' food sources group because of the undocumented nature of this mixed food offering.

A recommendation emerging from this research is that the emergency food basket, so essential in so many communities, could be improved if there was Government input into the type and form of donations (46,162). Such an idea would work towards a point where formal welfare benefit was sufficient to ensure no one needed to rely on a food basket.

Alcohol exposure

Nearly 10% of the exposure belonged to the category of pubs not offering food and pubs serving fast food (fast casual), so considerably increasing the availability of alcohol (163,164). Pubs not offering food, mainly sell high fat snacks such as packets of crisps, salted peanuts or cheese nachos (113). Fast and casual pub food includes fast foods, though they are often sold within a higher quality marketing atmosphere than takeaway fast foods (113). According to the Health and Wellbeing Survey 2016, the alcohol intake in Whitewood showed that over 20% of participants, recognising they exceeded the recommended weekly limit of consumption and recording being drunk during the week previous to the survey (120).

Shortt et al. and Wardle et al. found in 2014 and 2015 that deprived areas in Scotland, compared to wealthier areas have higher densities of alcohol,

tobacco and gambling outlets (165,166). In the report launched in 2018 “The ripple effect in Whitewood”, the residents described how increased alcohol and the availability of high-energy-dense foods availability, gambling opportunities and violent behaviour, crime rates, rapes, noise, among others, had significant and adverse effects (167). Macdonald et al. in 2018 also confirmed that in Glasgow, there is a higher number of alcohol outlet clusters by themselves, combined with fast food, tobacco and gambling outlets, within the most deprived areas (164). With regards to the obesogenic process, alcohol beverages also contribute empty calories to the daily energy intake (168). Although alcoholic drinks are not considered as food they contain considerable quantities of calories, thereby easily increasing the drinker’s body fat (168).

8.2 - Comparison of the obesogenic community food environment

The third research study objective was to assess the environmental exposure of the population to healthier and less healthy food sources within the neighbourhood. I proposed to identify the type of exposure and describe the distribution patterns of the food sources that shape obesogenicity in Whitewood. I confirmed that the presence and density of healthier food sources were very low. Predominance of the healthier sources category achieved only a 5.5% level (N=13) in Whitewood and 9.7% (N=23) in the overall foodscape. Supermarkets prevalence in the neighbourhood was just 1.7% (N=8) with a density of 2.6 outlets/km².

Regarding the remaining categories, I found out that there were very few: i) greengrocers, ii) fishmongers, iii) health food stores, iv) traditional convenience outlets, v) full-service restaurants and vi) wholesalers present in the foodscape. Their prevalence varied between 0.4% to 1.3% in the whole foodscape and the neighbourhood. Nevertheless, there were no wholesalers and full-service restaurants within Whitewood, which decreases the offer of healthier ready-made food and other nutritious products.

As in the predominance calculations, the density of healthier exposure within the neighbourhood and foodscape was very low, reaching 8.4 and 2.9 outlets/km² respectively. The concentration in the neighbourhood was higher than the whole foodscape. Analysing the densities by food source types in the neighbourhood, I obtained a similar trend that prevalence, where the highest density within this category was obtained by supermarkets (2.6 outlets/km²), followed by health food stores (1.9 outlets/km²) and greengrocers and delicatessen (1.3 outlets/km²). Fishmongers (0.6 outlets/km²) and convenience traditional outlets (0.6 outlets/km²) densities were the lowest. This confirms that though a resident can find in the neighbourhood eight of any of these healthier food outlets, if they want specific products as fish, they do not have enough availability of these products, as their presence was lower than one in the neighbourhood.

Supermarkets have been identified by most studies as the best proxy representative outlet for healthier food availability. Whitewood only had the equivalent of 2.5 establishments, a number considered low and worse if it is compared with the average density in the foodscape which achieved 1 outlet/km². My findings complement other studies reporting low levels or the nonexistence of healthier stores. For example, Mushi-Brunt et al. (98) who found nearly half of the participants did not have any grocery store in their neighbourhoods and Bodor et al. and Lopez et al. both reported that in their research neighbourhoods nearly 30% and 50% of the residents respectively did not have any supermarket in the area (59,73).

One of the few healthy food outlets identified was a greengrocer outlet which was open just four days per week within the Forge Market, leaving only one option to buy fresh products besides the few supermarkets and a couple of traditional convenience stores. Small convenience stores occasionally offered some fresh products, but these were limited in variety and consisted mainly of potatoes, lettuces, apples and carrots (55,56,66). The presence of any healthy type of outlet was minimal, there were no Farmers' Markets, as Leung et al. found in the US studies (56). In the case of grocery stores in the US, explored

by Cerin et al. and Zick et al. in the same country (67,77), the most similar types I found in the Scottish context were the traditional convenience stores, of which there only two. In comparison with other studies, exploring healthy food exposure, such as Drewnowski, Saelens et al., Bodor et al. and Dubowitz et al. (73,78,80,82) in the U.S. and Larsen et al. (89) in Canada and Miller et al. (85) in Australia, I included delicatessen outlets, which were not described in other studies. These outlets offer a mixed food availability, such as fresh products including ready-made vegetable salads and fruit salads.

The proximity analysis showed that on average, a resident has to walk 0.93 km from the centroid, in order to reach a healthier food store in the foodscape. This estimate is very similar to the general food sources mean distance, and for the same reasons; it is expressing the central values of a set of data. As is displayed in Table 5 in the results chapter, when observing the concentration of these stores across distance categories, there are statistically significant differences in the distribution of outlets across the categories. The results showed that nearly every three blocks from the centroid, residents could access to two or more outlets. The exceptions are the furthest categories within the neighbourhood and the foodscape, where there is no presence of healthier stores. This situation is concerning, as the last distance category within Whitewood corresponds to the neighbourhood boundaries, meaning that these parts of both residential areas have lower access to healthier foods if the residents want to buy within the neighbourhood. However, in the buffer area, the 1200 – 1500 m category (the first three blocks after the neighbourhood) were eight healthier outlets, thereby increasing the shopping options beyond Whitewood.

Analysing the spread of healthier outlets, I found the same pattern in the general distribution of food sources, where they were not distributed uniformly around the geographical centre. Observing the healthier food map (Figure 16), most of the food sources, (represented by green dots), were located in the northwest area, within the Forge complex and in the commercial hub. A minor proportion of the outlets are located in the northeast area (Shettleston Road

and Tollcross Road). It shows that households nearer to this area (over Gallowgate) have greater access to healthier food sources in comparison with homes located in Whitewood's southern area.

Walkable distances from the four distal points in each neighbourhood residential zone showed that residents have to walk between 0.35 and 2 kilometres, the equivalent of between 4 to 30 minutes to make purchases in one of these healthier stores. As both Drewnowski et al. and Story et al. pointed out, those living nearer might purchase more frequently in the healthier stores than those living further away as they involve easy walking distances (37,42). Laraia et al. confirmed via in-depth interviews that pregnant women preferred supermarkets but they were often located miles away from their homes, decreasing their frequency of shopping in those establishments (97). In 2018 the Social Market Foundation reported over 12% of survey respondents as 'not being near the right kind of supermarket' or 'affordable traditional convenience stores' as primary barriers to eating healthily (169). The study also showed that 16% of participants did not have access to a car to travel to a supermarket (169). The lack of access to transport is highly relevant and constitutes a significant barrier preventing access to healthier foods, by reducing the mobility of residents and increasing the dependence on nearby food sources (37,156).

The analysed measures: a) prevalence, b) proximity and c) density, suggested considerably deficient levels of availability and differential accessibility of healthier products in comparison with other types of foodstuff; a finding that applied to the whole neighbourhood. Availability and access are different among the residential areas within the neighbourhood and buffer zone and are even lower for those living further from the five food source clusters. As discussed in the scoping review, low availability and accessibility might act as barriers and decrease the daily shopping for these nutritious products, especially for residents living in the distal points of the neighbourhood and, as a result, negatively affecting the regular intake. Drewnowski et al. noted that healthier products are more expensive, which constitutes another critical

barrier to maintaining healthy eating among those with low-incomes (42). The Social Market Foundation study showed that 10% of the poorest households spend over 15% of their entire budget on food, representing 20% of household disposable income in this group (169). Jones et al., in the Centre for Diet and Activity Research (CEDAR) at the University of Cambridge, in 2012 analysed a ten year trend (2002 – 2012) of prices for healthy and unhealthy foods (170). They found that healthy products, such as fresh fruits, vegetables and meat cost about three times more per calorie than less healthy foods (170).

Food deserts

Whether the Whitewood neighbourhood qualifies as a food desert or not is still debatable. Taking into consideration one of the cut off points for food deserts established by the Social Market Foundation, which is *lower than two supermarkets per area*, this research confirms that this **neighbourhood is within the limit to be considered a food desert** (169). The presence of supermarkets in the neighbourhood reached two and a half establishments, which is very close to the cut-off point. However, taking into consideration the definition established by Shaw, the leading expert on food deserts, residents should have access to a healthier store within less than 500 metres (169). This information would point to **Whitewood already being a food desert for many people living in the neighbourhood**. The evidence shows that this less nutritious landscape is present in many deprived areas (46,47). Most of the studies confirming the presence of food deserts come from North America; however, there is evidence showing their existence in the UK and specifically in Scotland (76,169). In 2015 Mills and Wright found that in Durham, many residents live in food desert areas, with a lack of supermarkets and healthy stores (101). The participants confirmed that their main shopping was done in supermarkets, but they had to travel up to 15 minutes to reach these establishments. Transport and financial constraints were identified in focus groups as barriers preventing the purchase of healthy foods. According to the Social Market Foundation, Dalmarnock neighbourhood, which is contiguous to Whitewood, appeared as the most deprived in Scotland(169). Utilising this

data with my own research findings; it is feasible to suggest that beyond Whitewood the whole area could represent a larger food desert, which has significant repercussions for Greater Glasgow; specifically, and more generally for the health of Scotland's population.

It is not possible to ensure the in-store availability of the grouped food sources had the healthy proportions I had previously assumed without measure the consumer food environment. Some establishments considered as "healthier" might have a higher availability of less healthy food than others. Considering the limitations of the assumptions, I still relied on simple observation capacity, an informal assessment during the fieldwork and the literature reporting the availability of these types of food sources in order to analyse the quality of the exposure (27,37,46,101,109).

Considering the above and according to the findings, specific types of healthy foods such as fresh fish and seafood products are even scarcer than others (i.e. dairy products). There is only one fishmonger outlet in Whitewood and although other outlets as supermarkets and convenience stores also sell these products, they are less available than for instance, dairy products. This fact highlights that some essential food items for a balanced diet, are scarcer within the neighbourhood and the foodscape than others; thereby hampering the maintenance of a **food secure diet** (33). Low consumption of fruits and vegetables were revealed in the Health and Wellbeing Survey 2014/15, when it was found that only 21% of Whitewood residents eat more than five portions of fruits/vegetables, and 15% declared they did not eat any of these foods day (120). The same survey in 2017/18 found that only 31% of the population living in the 15% most deprived areas (included Whitewood) eat more than five portions per day (117). This figure is below the national average of 39% and highlights there is a significant deficit regarding what is desirable regarding a healthy food intake for the majority of disadvantaged people. While it is not possible to confirm whether the low intake levels regarding fresh fruit and vegetables are caused by food deserts or access barriers, I can at least suggest these two issues might be part of such barriers.

Food swamps

Within food swamps, the number and density of unhealthy food sources is disproportionately higher than healthier ones. The total number of less healthy food sources reached 27.7% (N=66) in Whitewood and within the foodscape 72.2% (N=172). The data indicate less healthy food exposure was high in both areas, but was stronger in the buffer than the neighbourhood. The fast food and takeaway category was the most predominant in the neighbourhood (8.8%), followed very closely by convenience stores (8.4%) and mobile food vendors (7.1%). Pubs offering no food, fast-casual pubs, restaurants and greasy-spoon type cafes, butchers, bakers, large and small discounts stores and candy/sweet/chocolates shops were presented in lower proportion (4.2% - 1.3%). In the lowest proportion were sandwich shops, gift shops, vending machines and entertainment-related sub-categories, such as clubs and associations, cinemas, amusements and ten-pin bowling (0.4% to 0.8%).

The average density of food outlets in Whitewood reached 68.1 outlets/km² and 21.7 outlets/km² in the foodscape. Densities by food source types followed the same trend as the 'predominance' factor. The fast food outlets and takeaways category (13.5 outlets/km²) showed the highest density, followed by convenience stores (12.9 outlets/km²) and mobile food vendors (10.9 outlets/km²). The remaining densities varied from 6.4 to 0.6 outlets/km². The measures of predominance and density represented the highest less-healthy exposure that Whitewood residents have almost every day and confirmed that Whitewood's residents were inundated by highly caloric food. In consequence, the opportunities to buy these products are very high and no matter where the residents are moving within the neighbourhood, the foodscape or what they want to buy, there will always be many chances to purchase snacks, fast food and processed products. Mobile food vendors are only open for football matches and school days, but they are able to increase the level of unhealthy food offerings quite considerably. I observed them for a couple of days and noticed the vans had a great advertisement for cheap promotions and large

portions during the whole day. Ready-made fast food is incredibly available everywhere.

As described at the beginning of this section, regardless of whether the outlet was a full-service restaurant, a takeaway café or a mobile food vendor, the food on offer was very similar. I observed an availability pattern in 20% (N=47) of the audited establishments within the neighbourhood and 8.4% in the buffer zone (N=20). The set of thirteen snacks and preparations involved:

1. Fried chips with or without melted cheese
2. Fried fish
3. Meat curry
4. Chicken burger
5. Cheeseburger
6. Hot dogs
7. Sausages
8. Kebab wraps
9. Pizza
10. Ice – creams
11. Pastries/doughnuts
12. Sandwiches
13. Nachos with or without melted cheese.

The 13 items were much cheaper than healthier foods; they were ready to take away and were frequently served in large portions. Among the outlets offering this type of menu were: mobile food vendors, fast – food outlets, takeaways, cheap cafes (often colloquially known as greasy spoon cafes), pubs, and fast-

casual and sandwich shops. This unhealthy menu was also offered partially in entertainment-related outlets, clubs and associations. Other more diverse Scottish, international or more 'nouveau' foods included: a) haggis burgers, b) bacon rolls, c) Indian starters (samosas), d) gammon, e) macaroni cheese, f) pulled pork/beef baguette, g) filled paninis, h) fish or meat pies, i) fried onion rings, j) waffles, k) cakes, l) chicken nuggets, m) baked potatoes, n) black pudding and o) mince pies. This finding describes what probably are the bestselling foods and how local food businesses already have identified consumers preferences. Mobile food vendors and the greasy spoon type cafes started opening very early, whereas fast-food, takeaways, pubs and convenience stores, were open until late, serving to increase the exposure to unhealthy food to up to 18:00 pm. Besides the mentioned proxies of unhealthy food sources used by other authors, such as Rundle et al., Black et al. and Mellor et al., I added a considerable list of new outlets (66,71,75). Beyond fast-food outlets, takeaways and convenience stores, I explored the categories and subcategories pubs, greasy spoon type cafes, bakers, candy shops, large and small discount outlets, gift shops, vending machines and entertainment-related outlets. Such outlets are present in the neighbourhood in lower proportions, alongside the traditional ones; thereby greatly increasing the exposure to less healthy foodstuffs.

The average distance from the centroid to less healthy food sources was, 0.94 km within the foodscape. This estimate is very similar to the general, and healthier food sources mean distance and for the same reasons; it is expressing the central values of a set of data. Table 5 in the results chapter shows that the concentration of food sources across distance categories is different from healthier food sources; a difference that is statistically significant. Findings have shown that if a resident walking from the centre point, can find between 25 and 35 'less healthy' food sources every three blocks in the neighbourhood, and between 15 and 31 food sources in the buffer. These figures are supporting the greater exposure of these foods throughout the whole foodscape.

Less healthy outlets are not distributed uniformly around the geographical centre, and as such follow the same pattern as exhibited by the rest of the food sources. Observing the 'less healthy' map (Figure 17), it is possible to distinguish that beyond the five concentration points that contain 65.1% of these food outlets, there is a lower but constant presence of shops spread across Whitewood and its surroundings. The densest points were the Forge Complex and the hub of commerce and services, confirming that households nearer to these zones have greater access to unhealthy foods in comparison to homes located in the southern residential area and northeast households. However, due to the higher density of these outlets, no matter if the access is higher in two zones, the rest of residencies still have very good access. This fact is very evident, especially in the south area, were light blue dots (representing food sources) are notoriously well spread across the households. Walkable distance from the four distal points in each neighbourhood residential zone is similar (0.35 - 2 km). By observing I was able to confirm they were at an easy walkable distance for many residents in both neighbourhood residential areas. In Cambridgeshire, Burgoine et al. found that close proximity of takeaways to homes was associated with a higher consumption level of fast foods, increased BMI and likelihood of obesity (Q4 v Q1; odds ratio 1.80, 1.28 to 2.53; $P<0.05$)(90).

On the opposite side, spatial analysis demonstrated an incredibly high availability and accessibility of less healthy products in comparison with healthier food in the neighbourhood and foodscape. If we consider that most prevalent and densest businesses were fast-food outlets, takeaways, convenience stores and speciality stores, it is highly likely that residents may frequently rely on these types of stores to frequently supply food for their consumption. Furthermore, there are so many additional places bringing many opportunities to buy and eat on the way out or back, 'take away' for home and even eating out of the home. As discussed in chapters 3 and 4, different authors such as Fraser et al. and Gibson et al. (55,72) have shown that increased availability and accessibility are strong promoters of unhealthy food purchases and a poor nutrient diets. Factors such as: i) short distances, ii) low

prices, iii) high availability of a tasty, unhealthy and satisfying set of preparations, together with iv) other less healthy ready to serve foods, selling through the whole day and until late at night, dramatically increase the purchasing frequency of highly caloric products (48,104,145). In terms of **food price**, a substantial amount of evidence has shown that unhealthy foods are very cheap. Jones et al. also found that in 2002, the price of 1,000 kcal of healthy foods was on average £5.65, compared to the same quantity of energy from less healthy food at £1.77 (170). They repeated the calculation ten years later and obtained that healthy foods price increased to £7.49 whereas less healthy foods cost only £2.50 for a caloric equivalent. Less healthy food prices are much, one might even say 'alarmingly', lower for a large number of products, including the set I mentioned as a "basic basket". Finkelstein et al. conducted a review about food prices and obesity and reported that low cost of fast-food and processed products, encouraging their consumption and the consumer's resulting obesity (171). Khan et al. found in Cambridgeshire that the higher density of fast food outlets and low prices were associated with higher intake patterns among 5th and 8th-grade children (172) .

This analysis affirms that **Whitewood is a food swamp**. Whitewood has some unique particularities as an emblematic football stadium and a large retail and shopping centre that are not present in other neighbourhoods; factors which influence food sources types and distribution patterns. However, I also identified some common elements of deprived community food environments that frequently appear in deprived neighbourhoods.

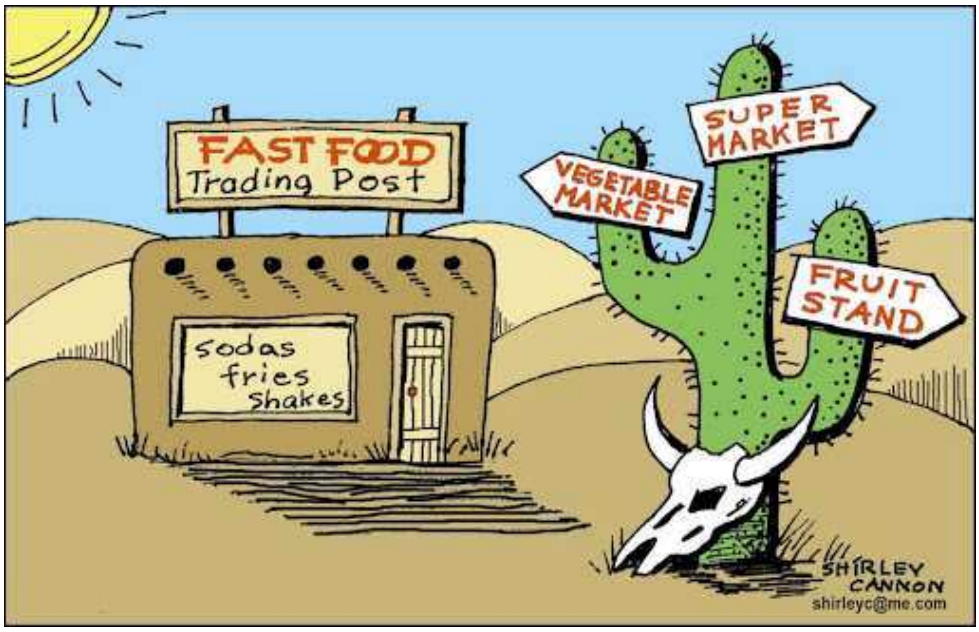
As discussed in the scoping review, global evidence shows that food swamps are a recurrent scenario in deprived areas. McDonald et al., Cummins et al., Maguire et al. Gibson and Burgoine have confirmed in the UK, the presence of food swamps in deprived neighbourhoods (55,76,90). Unhealthy foods have inundated the research neighbourhood and contributed to **a food-insecure diet situation** among the residents of Whitewood (33). The Scottish Health Survey 2018 reported 28% of men and 23% of women in the lowest income strata were food insecure (173). The HWS 2017/18 has shown rather alarming

figures about eating patterns (117). Around 38% of respondents in Glasgow consumed ready meals at least once a week: i) 43% of them consumed takeaways, ii) 67% consumed biscuits, cakes and pastries, iii) 55% sugary drinks, iv) 62% chocolates and sweets, v) 44% pies, pasties, sausage rolls, chips and vi) 43% crisps and nuts (117). Figures showing daily consumption are not as high as once per week but are still high; however, 19% to 32% of respondents admitted to eating processed snacks, confectionery, sweets and sugary drinks at least once per day (117). Findings also confirmed that participants living in the most deprived areas had more chances to access at least weekly consumption of sugary drinks, pies/pasties, takeaways and readymade meals than those living in less deprived areas (117). I cannot confirm the higher intakes of these products are caused by food swamps or high levels of access, but I feel it is reasonable to suggest can at least suggest these might be contributing components of those drivers that encourages their consumption.

Obesogenic community food environments

According to my findings, Whitewood should be considered as an **obesogenic community food environment**. The presence of a healthy food desert, co-existing with an unhealthy food swamp, creates an incomparable toxic foodscape for the neighbourhood residents; an issue I discussed in the scoping review. Much of the literature on obesogenic environments analyses either the unhealthy food environment or the environments where healthy foods are absent; only five studies reported them both together (56,58,62,78,87). As the illustration in Figure 18 creatively shows that both can co-exist in deprived areas and promote the obesogenic process differently. As explain in chapter 2 and 3 as the theoretical basis of this thesis, unhealthy food shopping reinforces unhealthy eating patterns and consequently, a sustained weight gain which will end in the consumer's obesity (5,8,37,80).

Figure 18 Illustration of an obesogenic community food environment



Source: Shirley Cannon illustrations. www.communityinnovate.org

Alongside the GIS measures, I calculated the Modified Retail Food Environment Index to observe the healthy food exposure proportion of my study area. The result showed that only 11.8% of food sources were likely to offer healthier foods. This finding is concordant with 9.7% of healthier food sources exposure I calculated within the foodscape. That calculation suggested that 10 out of 100 food sources within the foodscape have a range of healthy food that is available. According to this indicator, it is unlikely that the remaining outlets provide these types of foods. Lower scores, such as 11.8, also corroborate the presence of a food swamp and a food desert in the measured area.

All the barriers to buying healthy foods and all the opportunities to purchase unhealthy food are concordant with evidence analysed in the literature review (55,56,58,60–64,66–68,71–74,77–82,84–90,171). Residents are continuously discouraged within their community food environment from eating nutritious products because of their absence and yet are frequently encouraged to

consume highly processed snacks and fatty ready-made meals if they are out shopping or even just walking through the neighbourhood.

Cooksey – Stowers et al. and Holsten et al. have reported that the existence of a food swamp is a stronger driver of obesity than the absence of healthier stores (40,48). However, food deserts might be considered by default a potential driver of food insecurity and a contributor to unhealthy eating behaviour. From an energy consumption perspective, it makes sense that “the excess of calories” is one of the main reasons for an individual to become obese (8,27). A lack of nutritious food is indirectly facilitating the unhealthy behaviour and ultimately causing food insecurity and weight gain (35).

Different studies have proposed that community food environments are not the most critical environmental contributors to obesity (37,104). Organisational food environments (worksites, schools and other places where people spend a considerable amount of time) might be even more relevant in terms of influence (37,104). It is a fact that people move from the neighbourhood to other sites to work, study and develop other activities. It means that residents are exposed to different food environments. Burgoine et al. using the Fenland study UK sample, found that on average, worksites and commuting food environments, contributed at least equally to local neighbourhoods, which represented around 30% of total food exposure (104). Whether this calculation could be extrapolated to other neighbourhoods, such as Whitewood, the weight of the residential food exposure would be nearly a third for an average resident. As I discussed in the literature and scoping review, it is logical and expected that vulnerable low-income groups, such as the elderly, unemployed, children and even single mothers could have a higher obesogenic neighbourhood exposure due to their reduced levels of physical activity (37,80). However, this proportion may vary among the different contexts and also at individual levels.

It is important to contextualise the community food environments obesity contribution within a “big picture”. As I described in Chapter 3, community food environments are not the unique and only important obesity cause. Other

potent drivers at micro and macro levels are also highly relevant to consider in the obesity causality model (7).

The foresight programme has highlighted that community food environments are part of a complex network influencing individual and family choices, which are themselves perversely reinforced by poverty and social inequalities (7,8). At the macro level, how the food systems contribute to obesity is highly relevant. An important part of the food chain, from production to the products arriving in the shops, might be considered part of the obesity determinants (33–35). Just two examples to illustrate their influence are:

a) the production of inexpensive and low quality foods facilitates their availability in deprived neighbourhoods, which also are intensively promoted by the food industry (through social media) and shop owners to encourage their consumption; and (35)

b) on the opposite side, all the barriers to produce, distribute and store fruits and vegetables increase their price, decrease their availability and therefore discourage their consumption (35). These dynamics are unfair for the customers, especially those under economic constraint as well as poor quality living conditions. These disparities are notorious and strongly influence the eating patterns among low-income households (7,35,42). A lack of multilevel food policies means a lack regulation for food systems, the food industry and local premises. Food availability and prices are also affecting purchasing habits within neighbourhoods, especially in those low-income settings (42,171). These macro factors, combined with poverty, are powerful obesity drivers and have a domino effect on both micro and individual factors, facilitating obesogenic behaviours from different angles (4,7,16,61).

Among other recognised relevant drivers of eating behaviours at micro level are: i) food culture, ii) poor cooking skills, iii) lack of refrigerators iv) lack of a kitchen in which to store and prepare food, v) poor time management, vi) high levels of food insecurity and vii) unhealthy food habits from childhood. Food culture is nowadays associated with the rapid purchase of ready-made and

processed foods (173,174), high in fat, high in sugar, high calorie diet, full of global preparations, such as hot-dogs, burgers and kebabs (74,76,77). This high demand for less healthy foods products can also attract more of the specific type of business that focus their availability on these bestselling and inexpensive products. So, customers are also influencing the type of food environment they want, which they can afford and which is familiar; in many cases due to consumption from infancy (4,7,16,37). The desire to eat meals with large volumes, in case there are food shortages later, and the purchase of ready-made meals because of the lack of equipment to store and prepare other foods, shape decision making regarding what to eat. These potential drivers are reinforced at the same time by a deprivation amplification effect, which facilitates both unhealthy food purchasing, and therefore unhealthy eating behaviours (7,8). In other words, poverty is informing individual and family obesity social determinants and biological risk factors (related to occupying an insecure socio-economic position) (4,14,16). In consequence, poverty is an essential part of the structural roots of the highlighted health inequities and environmental injustice (4,16,175).

This chapter has discussed the main characteristics of the built and community food environment in a deprived neighbourhood of Glasgow, Scotland. The study has identified spatial disparities and poor living conditions, as observed during the fieldwork. The chapter also analysed the general features and distribution patterns of the food sources composed by the foodscape, as well as the absence of other food outlets, which used to be, and often still are, present in more affluent areas. Also discussed was the role of other food sources related to deprivation: a) charitable organisations and their potential role in the eating patterns and b) the impact of pubs in the high alcohol consumption rates. Finally, the researcher has analysed the obesogenic community food environment found in Whitewood and compared the study's findings with those reported in the literature. The analysis was focused on the presence of: a) food deserts and b) food swamps, their distribution patterns and the potential impact of the availability of, and accessibility to, healthier and less healthy foods on residents' food purchasing habits and dietary patterns.

Chapter 9 – Conclusions

This chapter provides an outline of the most relevant food policies implemented at national and local levels and brings forward recommendations to improve food environments and future research. It concludes with a summary of the most important features of the PhD and a personal reflection of the academic journey.

The objectives of the chapter are:

- to discuss local and governmental policies outlining strategies for improving food environments
- to provide recommendations for the food environment improvements based on the research findings and international and national evidence
- to provide recommendations for future research
- to summarise the key messages emerging from the PhD
- to reflect on my research experience and personal journey through the PhD programme

The chapter is divided into five sections:

Section 1 discusses the implementation of national and local policies and their impact on improvements to food environments in the last decade.

Section 2 discusses the most relevant policy recommendations to improve food environments.

Section 3 describes the main recommendations for future research, taking into consideration the strengths and limitations of the present study and the relevance of the topic for public health and the research community.

Section 4 summarises each step of this PhD in order to successfully conduct this study.

Section 5 offers a brief reflection of my personal PhD journey

9.1 – What Glasgow Council and the Scottish government are doing on this matter

The Scottish government has developed various different strategies to tackle the obesity pandemic that exists within the country. In 2007, after a series of alarming reports published by the Foresight Programme, public policies were developed with the aim of controlling the population's rapidly rising obesity levels (7,8). During the period from 2008 to 2009, the Scottish Government held several meetings with experts from civil society and the third sector to develop long-term health related strategies. By 2010, Scotland had the highest levels of obesity among the OCDE countries (21). Discouraging projections estimated the levels of obesity to increase by 40% by 2030 if the 2010 situation continued (21). The same year, the government launched the *Food and Drink National Policy "Recipe for Success"* and a *Route Map to Prevent Overweight and Obesity* (176,177). The policy was primarily focused on the regulation of unhealthy products in the food and drink industry (176). However, the policy was also intended to foster collaborative working between product producers and schools to provide the promotion of healthy habits among schools (176). Regarding communication strategies, the government sought to improve health promotion within communities as well as initiating school educational campaigns. The policy also outlined the obesity route map, which contained a set of agreed actions which, in collaboration with the private sector, was designed to tackle obesity (176,177). Both initiatives worked together with other key organisations to encourage a balanced, healthy diet among children and young people. The strategies specifically related to food environments are stated below:

- Alongside the Scottish Retailers' Forum, the government proposed a reduction in the in-store **ratio of energy-dense food** and to **decrease high energy drink options** (e.g. through smaller and less energy-dense portions) (176,177). Reducing the ratio was expected to improve

the availability of healthy food options, in addition to a reduction in portions sizes (176,177). The target outlets were supermarkets and convenience stores due to their popularity amongst consumers (as discussed above).

- The joint work of the Food Standards Agency and the Food Implementation Group (FIG) supported the industry **to improve the nutritional characteristics** of their products by reducing levels of salt, saturated fat and sugar, and portion sizes (176,177).
- The joint work alongside the Scottish Grocer's Federation (SGF) and the FIG group implemented the Healthy Living Programme. The programme encouraged neighbourhood food shops to **improve the nutrition standards of the consumer food environment**. This goal could be achieved through, for example, removing confectionary from till stations, and by expanding the range of healthier choices such as those promoted by the scheme (176,177).

I also searched for Glasgow City Council's strategies against obesity. I found that in 2009, in parallel with the national policy, the council launched the *"Healthy Weight Action Plan"* in partnership with relevant local organisations (Glasgow Life, Glasgow Centre for Population Health, NHS Greater Glasgow and Clyde, Community Health and Care Partnerships and Glasgow Community Planning Partnership) (178). The first priority action area was to control **the sale of obesogenic foods and drinks** (178). The following improvements in food environments were proposed:

- To improve availability of healthy food and drink options in vending machines in GCC.
- To increase the availability of healthier food options in Glasgow community centres cafés
- To boost incentives for food businesses to offer healthier options

The food and drink national policy of 2009 and the route map action plan 2010 were considered sound. Both sought: i) to increase the availability of healthy

foods in essential critical outlets like supermarkets and convenience stores, ii) to enhance the consumer food environment, and iii) to decrease portion sizes. Working with the industry was another strategic goal to enhance the nutritional quality of processed products (176,177). However, analysing the investment made by the government between 2008 and 2011, which sought to increase free school lunches and improving physical activity strategies such as “sportscotland”, active schools, and the creation of cycle pathways, I could not find any indicator or report showing concrete improvements and an evaluation of the impact of either initiatives (179).

Similarly, I did not observe any significant neighbourhood improvement in my study area in 2018. Based on my observations, the policies implemented at the national level since 2011, apparently have not reflected any increase in the availability of healthy foods in Whitewood’s supermarkets, convenience stores, fast-food restaurants and takeaways or any decrease in food portion sizes. On the contrary, the availability level of unhealthy foods in Whitewood was significantly higher than the availability of healthy options; furthermore, the portion sizes were larger than ever. Observing the processed food labelling available in the neighbourhood, there appeared to be a modest improvement in the nutritional content of some processed products, although it is evident there is still a long way to go.

Furthermore, apparently very little has been done to implement the Glasgow Action Plan in Whitewood (178). During my fieldwork, I confirmed that no healthy food choices, such as dried fruits, dairy products, zero sugar soft drinks were present in the vending machines located both in the Forge shopping centre and the community centres. Regarding incentives, neither study presented specific data about it. Considering the lack of healthy options, I observed in the consumer food environment, I presume there was little improvement in this issue.

Recent national policies may promote more promising changes. After the Scottish Government committed to improving food environments in the 2017-18 *Public Health Priorities Programme*, two new policies were introduced last

year (180). These policies sought to continue supporting prior actions whilst adding new measures to improve nutritional status outcomes through the *Good Food Nation Policy* and the consultation of *Glasgow Food Policy Partnership (GFPP)*(181,182). The Good Food Nation started a consultation in 2014 and is still being improved to be legislated as soon as possible. The policy is incorporating in the proposal the right to food, starting from the base that the access to healthy and adequate food is a basic right for everyone in Scotland. Though the first set of measures were implemented in 2018, planning is still ongoing. Similar to preceding legislation, the policy aims to improve food security and decrease obesity rates among the Scottish population. The proposed essential measures for improved food environments in the 2019-2020 programme are as follows:

- Implement the **Healthcare Retail Standard** (HRS): In NHS (National Health Service) food shops, 50% of all food products (such as fresh and canned vegetables; frozen fruits; beans and pulses, fresh, canned and frozen fish, low and medium in fat dairy products)(181,182). Also 70% of drinks should be considered healthy (lower in fat milk and yogurt, soft drinks at least 70% sugar free and flavoured waters with less than 0.5 % sugar) .
- Continue with the **Healthy Living Award**. This is a national award for foodservices offering healthier choices. This initiative is a voluntary measure and work is currently underway to enhance the effectiveness of this incentive.
- Continue with **Healthy Living Programme**: continuation of the scheme for convenience stores, still managed by the SGF
- **Small and Medium-sized Enterprises (SME)** Reformulation: as a continuation of the joint work started with Food Standard Agency; however, this time in partnership with Food and Drink Federation Scotland. Its purpose is to provide expert advice on reformulating food and drink to meet calorie and nutrient content regulations.

The Good Food Nation programme, as well as the predecessor, Food and Drink National Policy, is a wonderful proposal. However, following its first year of implementation, the level of improvement was found to be lower than was expected (183). This outcome is most likely because shops' adherence to the programme is still voluntary. An example of this is the Healthy Living Programme which, according to the official figures, enrolled two-thirds of convenience stores (40% of them located in deprived areas) (183). They are now offering pieces of fruit and are advertising healthy eating habits such as the "eat better, feel better" campaign. Although this 'offering initiative' marks a positive change, it is just the starting point for businesses. To make a significant impact, the government confirmed that every NHS outlet has to be participating in the programme (183). This programme will be most powerful if changes are implemented in all types of food sub-environments, in both the short and long term. (11–13). Details about policy improvements are described in the next section

Regarding the rest of the key strategies, the most notable improvements were obtained by NHS shops, as compliance was mandatory for all establishments. The evaluation showed that improving the availability of healthy foods incentivised a healthier purchase (183). The Healthy Living Awards consultation finished successfully, with improvements such as mandatory calorie labelling at the point of choice, including ready-made food (183). Finally, the government invested £200,000 in the reformulation of commonly consumed products to lower calorie content over a three-year period (183). The impact of this intervention will be assessed in future evaluations.

In line with the policy, at the local level, the last and most novel initiative can be seen in the Glasgow *Food Policy Partnership (GFPP)* (181). The group is composed of a range of public, private and voluntary sector organisations, each of which declared they "share the ambition to make the food system in Glasgow fairer, healthier, more sustainable and resilient"(181). Currently, their proposal is under consultation, supported by the *Glasgow City Council Strategic Plan 2017 – 2022* (184)*;* its focus is on strengthening the strategies

established by the Good Food Nation policy. The vision of this local strategic plan is to transform Glasgow into a healthier and more sustainable food city (184). They aim to do this through a new neighbourhood empowerment approach. The specific actions are to reduce the calorie content and portion sizes of food products, ensure detailed nutritional labelling, enforce marketing regulations and increase healthier food availability.

In 2018 Lake et al. stated that no nation in the world has managed to reverse their obesity trends (185). The Good Food Nation policy is consistent and the potential impact over obesogenic food environments is promising (183). If the plan is supported by the Glasgow Council and GFPP proposal (181), there is likely to be a sustained advance in the quality of Glasgow City's nutritious food availability and accessibility. However, future interventions need also to expand their actions, adopt a stepwise approach and ensure changes are implemented at both a micro and macro level. As I described in the previous chapter, when discussing the key aspects of the causality model, it is important that actions are directed downstream to micro and individual factors and upstream to regulate food systems and global markets (4,7,14,35,186). These interventions are more likely to reduce poverty and significantly improve the living conditions of those in deprived areas. As discussed, these changes are crucial in order to tackle the core problem of health inequalities, rather than expecting food policies to act alone (33-35). According to a report by Loring and Robertson, *Obesity and Inequities:* "unless equity is explicitly taken into consideration, the business-as-usual approach tends to create policies, programmes and services that have a social gradient in their effect" (4). If these policies are well articulated and implemented actions based on the social determinants framework, would constitute an enormous advance in social justice and the reduction of structural inequities. To decrease environmental inequalities is a government debt to reduce the historical **Glasgow effect**.

9.2 – How to improve obesogenic food environments

To reverse toxic food environments, where some of the most vulnerable people live, requires multi-sector input and action. As I described in Chapter 3

and previous sections, the food environment is part of a complex urban system, and is composed of many different layers or subtypes (community, consumer, informational and organisational)(37,38). Interventions in each food environment subtype must occur simultaneously and should consider its connection with the food systems and the network of obesity determinants (4,7,14,186). These interventions must also prioritize poverty and other structural factors, such as income and education (4,14,186). As I discussed in the previous section, in order to influence food behaviours, different strategies have to be implemented nationally with local pertinence to introduce positive and sustained changes to the food environment. The *Good Food Nation policy* and the *Glasgow Food Policy Partnership (GFPP)* are great examples of macro and micro-level strategies that offer coordinated actions in cooperation with the third sector, NGOs and civil society to tackle food insecurity and obesity.

To improve **community food environments**, the regulation of food premises numbers and types is essential in establishing a new balance between healthy and less healthy food exposure as well as decreasing the environmental inequalities (36,185). Limiting licensing of less healthy outlets, i.e. fast-food chains, pubs and takeaways will decrease the presence of food swamps and consequently residents' exposure to unhealthy foods (36,185). According to Ashe et al., utilising local government power over land use may be an efficient measure to mitigate the rising epidemic of poor nutrition (187). On the other hand, promoting the presence of farmers' markets, supermarkets, grocery stores and other healthier outlets with high food quality will decrease the presence of food deserts and likely have an impact on diet quality and other health outcomes (46,47,188,189). Taking into consideration my findings, I would also encourage the opening of different food premises that are usually part of wealthier community food environments. This incentive would give more chances to buy a wider variety of foods, such as those from 'organic' shops and producers' stores. Incentives must include a national or local subvention to support both the opening of these stores and to maintain competitive prices when compared to less healthy foods (4,190). It has been

proposed, that even the budget can come from less healthy food taxes (4) as is the case of Hungary and its policy “Public health product tax”; income which, in part, is used to promote and shape healthier community food environments (191).

Additionally, urban redesign might guarantee a more equitable and strategic distribution of healthier food sources across residential areas. Consequently, such development would facilitate accessibility for all residents, especially those with low-incomes and limited mobility (the elderly, parents with children, residents without cars, the unemployed) (185,192). This measure is challenging in the long-term but would contribute significantly to reducing levels and examples of spatial inequity. Lake et al. also proposed that fast food and other unhealthy food outlets should be restricted in number in specific areas, such as shopping areas (185). It was also recommended that fast food outlets should be placed some distance from settings such as schools and residential areas (185,192).

To enhance **consumer food environments**, mandatory regulations to increase the in-store content and presentation of healthy foods must be progressively introduced (190,193). These regulations should be implemented specifically: a) in fast food outlets, b) in takeaways and c) in convenience stores (192). According to my research such outlets are more concentrated in deprived residential areas and are usually within easy walking distance from residents’ homes. The example of NHS shops would be adequate, where 50% of the in-store food availability and 70% of drinks are healthy (182). This would perhaps be an excellent opportunity to set up a *“healthy food basket”*, creating a set of nutritious and affordable preparations that might be easily available in most of the food sources. This strategy was implemented in Slovenia, which created a ‘healthy food basket’, informed by the national dietary guidelines and data about people’s food intake according to their socioeconomic status (47).

Evidence from the literature, in corroboration with my research results, supports the need to decrease the food portion sizes and to label the ready-made food in order to achieve a significant reduction in the incidence and

development of obesity (43,143,188,190,193). All types of sources could be encouraged to increase the availability of their healthy offerings (4,41,185). Beyond fast food outlets, and based on my observations, restaurants and cafes, speciality stores, social and entertainment-related outlets and discount supermarkets might also improve the quality of their foodstuffs (192). This action might reduce the number of 'greasy spoon' outlets, transforming them into more attractive places to eat, or at least from which to buy food. To foster these changes, there is a need to provide technical support and create incentives for retailers to implement the required changes (4,182). These might be excellent strategies to improve the type of content they offer, including the in-store publicity (37,43). As I discussed previously, the healthy living programme aimed at convenience stores is another good strategy to promote all the aforementioned changes (182,183).

Considering my findings, and previous public health initiatives such as project Mura in Slovenia, I also propose the idea of introducing healthy snacks in community centres and clubs, as well as free cooking classes for residents (4,194). Although this initiative might be implemented only in some neighbourhoods, it would be an excellent complementary initiative for deprived settings. The Mura initiative has 5-year governmental funding support, and incorporates community participation, health education, and food preparation in establishments such as community centres and schools (4,194).

I have identified several needs to improve healthy food availability in food banks. I would strongly recommended an official government policy to enhance and regulate the emergency food baskets, ensuring availability of appropriate quantities of fresh fruits and vegetables, with slightly lower availability of dairy products (139,160). I would also recommend selecting low salt and low sugar canned fruits, breakfast cereals and other high-energy dense foods (160). These adjustments will help to ensure the nutritional requirements of the recipients are met. Furthermore, the regulation of food outlets opening times might contribute to limit the exposure to unhealthy foods,

considering that on average; less healthy food outlets are open longer than healthy ones.

Finally, price regulations have been suggested as another potentially effective measure to discourage less healthy eating and promote healthy eating patterns (171,188,192). Huang and Lin showed that a 10% price reduction of fruits and vegetables increased their uptake by 7.2%. As the increase in the provision of healthy products would be expensive, a governmental subvention of fresh products might be introduced (43,189). Supporting producers and shop owners will guarantee healthy snacks and drinks with competitive prices compared to other products (193). Story et al. have also proposed that connecting producers with shops owners could help to secure not only better prices but also higher quality products (37). Such an initiative is likely to promote sustainable food environments (17). The incorporation of a tax for high-energy dense foods and beverages has been proposed in countries like Canada and the UK (188,192,193). The US, Denmark and Hungary have already implemented the taxation of sweetened drinks and high-in-fat foods as well as fast foods (Zhang et al) (195). The price increment is likely to discourage the consumption of unhealthy foods; however, the strength of that discouragement is yet to be fully seen and evaluated (4,171,192). The regulation of price promotions is also crucial. Promotions are a key driver of shopping behaviour and consumer spending (37,185). In 2014, the economic and social research council published a briefing paper showing that the promotion of unhealthy foods applied to over half of all food products sold in UK supermarkets, resulting in over £50 billion per year in consumer spending (196). Restricting such promotions might discourage overconsumption of these types of products (196).

Regarding the **informational food environment**, the regulation of advertisement in media and in-store, has been recognised to have an impact on food shopping, especially in the purchase of processed products for children (36,197). Scully et al. suggested that high exposure to food advertising might be shaping food selection, beliefs, and purchase requests

(198). Fewer advertisements for high-energy dense food, sugary drinks, and alcohol beverages could decrease the levels of their sales (192,195). On the other hand, increased publicity and education of healthy foods through television, radio and other media campaigns could have a positive impact (152,197).

Finally, the **organisational food environments** require multiple interventions and healthy food promotion in work environments, homes and schools. The regulation of the other environment subtypes is essential due to people spend an important amount of time in these environments (37,96). One clear example I observed in Whitewood was that street vendors were often located outside schools during the academic year. This situation greatly affects the exposure of children to unhealthy obesity promoting foods and must be regulated by local authorities (36,96,115). Regulation of schools and worksite environments will ensure a healthier food provision in cafeterias, affordable prices for healthier preparations, healthy snacks in kiosks and vending machines and other places offering food within these establishments (37). The introduction of healthy improvements in school meal programmes would improve the quality of the offer substantially (182,188). Additionally, educational campaigns and health promotion in each of these micro-settings are key strategies to protect a food secure diet and a normal BMI among students and workers (98,188).

The Good Food Nation Policy and GFFP are focusing on the consumer food environment, as well as on the informational (marketing) and organisational (schools) environments' regulations (181). Although to work with each aspect of the food environments is the best strategy, to incorporate the community food environment in the policy package might be the most challenging but effective solution to the challenge of ensuring healthy eating. It is essential to expand their actions to the community food environments, which probably are the most difficult to improve due to the necessary spatial redesign and strict regulations existing in most premises (156,185). Taxation is another highly

debated topic which will likely require firm legislation to overcome objections in the form of opposition from the food industry and businesses owners (4,193).

Macdonald et al. have discussed that overprovision of harmful food in deprived areas is a form of 'environmental injustice' (164). Similarly, Kavi et al. have pointed out that limited availability and access to healthier food sources that provide affordable food options is another form of 'environmental injustice' (199). In other words, both statements emphasise that food swamps and food deserts are ethically as well as physically unfair. Food security is a human right that has to be guaranteed (35,183). The Good Food Nation policy incorporated the right to food as its central principle (182,183). It will undoubtedly take several years to see a significant positive impact in a city known for its deprivation history and the negative effect such deprivation is still having on its residents.

One other crucial consideration in the enhancement of food environments is the need to tackle poverty together with the associated structural determinants of health inequalities (7,14,186). Poverty brings inequalities in a life-course approach and at all levels of living conditions (4,14). Incorporating policies similar to those implemented by the Government of Slovenia to ensure that the welfare payments are sufficient to cover the monthly costs of the healthy food basket, described above, may be a good starting point (194). Of course, educational campaigns are needed to create awareness of the importance of healthy eating to address the spend of the household budget on the basket and not on other products (4,192). These campaigns is just one example of many efforts that have to be made to improve income and quality of life; otherwise, food environments policies will not be effective (47). Loring and Robertson, in their report for the WHO, remarked on the urgent need to improve income distribution at a global level (4). Raising wages of the most economically disadvantaged groups, through social protection, and redistributive taxation may enhance living conditions and decrease the environmental inequalities gap (4).

9.3 – Recommendation for future research

More research is needed to document and map in detail other deprived community food environments and analyse the association with obesity at a local level. A mixed methods research approach should combine spatial and nutritional analyses with in-depth interviews to confirm food purchasing behaviour and the impact on eating habits that I am assuming here, based on previous evidence. As previously proposed by other researchers, complementary to the use of static spatial analysis, activity exposure measurements can also be incorporated into future research initiatives (200). This methodology captures individual exposure during a determined number of days (200). With this data, it is possible to assess participants' daily routes and analyse different exposures they have during the day. It is essential to acknowledge that residents and citizens move between different community food environments every day (200).

The assessment of both the community's environment and the nutritional consumer food environment is highly recommended in order to corroborate the food source availability and to classify the food sources accurately. Besides, the analysis of all types of products, promotions and food distribution existing within the food sources will provide valuable data to describe other obesogenic elements that are influencing food shopping. Adding some elements of the informational environment, such as in-store advertising, may also be useful to understand the influence of publicity over an individual's food purchase. Such an approach could well be applied with the healthier and less healthy food categories in other settings and regions in the world. This exercise will give the space to compare and understand better the obesogenicity of food environments. Finally, it may be valuable to explore a more objective

measurement of a healthy and less healthy food basket, to understand the most popular products and the consumers' preferences.

9.4 – PhD summary

In this PhD I aimed to establishing process of mapping the community food environment in order to identify contributors that shape obesogenicity in a deprived neighbourhood in Glasgow City, Scotland in order to determine the factors and features that shape obesogenicity. To achieve this aim, I first developed an innovative study design and methodology, combining a geo-spatial, nutritional epidemiology and public health approaches, to map the community foodscape of this neighbourhood. The foodscape allowed me to describe the unique and general features of the deprived community food environment and to assess the physical exposure of the population to healthier and less healthy food sources within the neighbourhood. I conducted a comprehensive scoping review, which is itself a valuable and updated piece of evidence, in order to cover the gaps related to a) the relationship of community food environments and obesity in the UK, US, Canada and Australia and b) the methodological approach required to develop a foodscape. The analysis of the evidence provided me with the rationale to compare and discuss the main findings of the thesis that are also divided in the same order: i) the community food environments and their potential obesogenic influence and ii) the methodological aspects of the research. Considering the later, the scoping review provided me the evidence to prove two hypotheses that stated at the beginning of my research: food sources were under represented into the foodscapes' studies and the assessment of the obesogenicity was incomplete.

As a result, I created a detailed foodscape which was mapped within consensual neighbourhood boundaries as well as including an expansive buffer area around the neighbourhood. The foodscape incorporated all the physical and open-to-the-public food sources where potentially the residents of Whitewood might be able to obtain food. The map also included rigorous

data source validation and classification, which allowed me to identify and describe the type and accessibility of a wide range of outlets, including healthy and less healthy food sources, informed by the context of deprivation.

In my findings, I describe the general deprived community food environment within Whitewood, highlighting the high prevalence of pubs, entertainment related outlets and food aid, before discussing their roles as food sources, as well as facilitators of alcoholism and gambling. I characterised absent food sources as organic stores, produce vendors and farmers' markets, and compared the research site with wealthier community food environments. This latter initiative, by including such details, constituted an achievement that has not been described before.

The analysis of healthy and less healthy food sources let me identify the existence of both a food desert and a food swamp, together with their distribution patterns within Whitewood. These findings permitted me to test and prove my third hypothesis which stated that using the correct methodology, Whitewood neighbourhood has an obesogenic food environment. According to the theoretical basis of this thesis, and what have been proposed by the most relevant authors on the field, higher availability and accessibility of less healthy products might encourage an unhealthy food shopping and eating behaviours. I also pointed out the difficult challenge of creating a healthier food environment; a deficit resulting in ever-increasing levels of obesity over time. I contrasted this evidence with the findings analysed in the scoping review, which identified similar results in other regions of the world, but with similar deprived or impoverished neighbourhood settings.

As part of my conclusions, I also described the main food environment policies implemented in Scotland in the last decade and contrasted those policies with my findings relating to the degree of impact they have had in Whitewood. Based on this model, I proposed a package of initiatives that might improve the food environment considerably. The most crucial part of the improvements must be made at the structural level, reducing poverty and inequities among the most disadvantaged people living in one of the most deprived places in

Scotland. Such residents are the people most affected by health inequalities, including obesity. However, beyond the high burden of disease, there are deep routes of environmental injustice and health inequalities that has been historically described in Glasgow as the 'Glasgow Effect'.

Limitations of this research are well described. It is the type of design that does not permit to measure changes of the community food environment over time or to confirm the influence of the measured variables over residents' obesity. However, its adaptation to local context and resources might be possible. Study area delimitation and interruption of the fieldwork might affect the data validation and exposure measurement. Furthermore, the replication of a study with these characteristics is probably not possible to replicate again due to it might be expensive and long to monitoring foodscape changes as a public health tool.

Among the strengths I can proudly say this is the first study in Scotland and as far as I know, in the world, which has explored a single deprived neighbourhood to analyse in detail the community food environment and obesogenic exposure in a deprived context. As such the study constitutes an updated and original piece of evidence that I hope will contribute to local authorities' policy makers as well as to future community food environment research.

Additionally, although it was not one of the research aims, I described a set of less healthy foods in what I proposed as "a less healthy food basket" which was: a) fully available in nearly 30% of the audited outlets and b) partially offered in a significant number of the remaining food sources. This basket data constituted another important precedent for food environment research and local authorities in Glasgow; as far as I know this is the first time such a concept has been described and documented.

As Lake et al. pointed out, no country in the world has reversed its obesity figures as yet. More than ever, rigorous research is needed to document in detail other deprived community food environments and to identify and then

analyse any association with obesity at the local level. The analysis of poverty is essential in order to undertake effective interventions aimed at the root causes. Mixed methods research and the use of activity space methods might be useful to confirm food purchasing behaviour, as well as the impact on eating behaviours that I am assuming here.

9.5 – My academic journey

During the years of my PhD I learned the importance of conducting rigorous research. I have the good fortune to have trained in the US, Switzerland and the UK and to have been able to connect with recognised experts which helped me improve my knowledge about neighbourhoods, food environments and spatial analysis.

My investigation faced many challenges in terms of methodology and fieldwork. Developing the most sensitive methodology was challenging, and I made several trial and error episodes in order to build the final foodscape. Each step constituted left me either frustrated on some days or happily optimistic and excited on others. The result was a wonderful food map of the sort I had not seen before, and which will allow me and hopefully many others to develop explicit and detailed food maps in the future.

From a nutritional point of view, the healthier and less healthy food sources classification was challenging. Although there are still limitations that might be overcome in future research, I believe that my efforts to go beyond the traditional 'unhealthy food' concept, by: i) incorporating levels of food energy

in a wider classification and ii) releasing an updated way to observe healthy and less healthy food outlets sets out new strategies for obesogenic research..

One of the toughest parts was the fieldwork interruption for safety reasons. Thankfully, I had almost completed all visual inspection, but just at the end the area presented risks that meant that I was not able to return to the site. I therefore in this final stage looked to alternative methods corroborating my data using other data gathering methods, rather than direct observation. The field validation constituted a wonderful experience that led me to observe another neighbourhood, together with its food environment characteristics, that improved my research and allowed me to grow as a researcher.

Food environments are more complex than the literature reflects. Poverty and deprivation are tumours spread across these types of the urban areas that must be dealt with for the good of the residents and society as a whole.

As a nutritionist and public health professional, I learned that foodscapes can facilitate an understanding of the differential food exposures within local vulnerable micro areas and also help the decision-making processes of local authorities. I also realise the relevance of tackling health burdens from their roots. Without that approach all intervention, no matter how great or well-intentioned they are, will ultimately be ineffective.

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Appendices

Appendix 1 Protocol systematic review

Exploring the relationship between local food environments and obesity in UK, Ireland, Australia and New Zealand: A systematic review protocol

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ABSTRACT

Introduction: Obesity is a global pandemic that affects all socioeconomic strata, however, the highest figures have been observed in the most disadvantaged social groups. Evidence from the US and Canada showed that specific urban settings encourage obesogenic behaviour in the population living and/or working there. We aim to examine the evidence on the association between local food environments and obesity in the UK, Ireland, Australia and New Zealand.

Methods: Six databases from 1990 to 2017 will be searched: Medline (Ovid), EMBASE (Ovid), Scopus, CINAHL, ASSIA and Web of Science. Grey literature will also be sought by searching Opengrey Europe, The Grey Literature Report and relevant government websites. Additional studies will be retrieved from the reference lists of the selected articles. It will include cohort, longitudinal, case-study and cross-sectional studies that have assessed the relationship between local food environments and obesity in the UK, Ireland, Australia and New Zealand regardless of sex, age and ethnicity of the population. Two researchers will independently select the studies and extract the data. Data items will incorporate: author names, title, study design, year of study, year exposure data collected, country, city, urban/rural, age range, study exclusions, special characteristics of study populations, aims, working definitions of food environments and food outlets, exposure and methods of data collection,

outcomes, and key findings. A narrative synthesis and a summary of the results will be produced separately for children and adults, according to the type of food exposure–outcome. All the selected studies will be assessed using The Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

Ethics and dissemination: this study will be based on published literature, and therefore ethical approval has not been sought. Our findings will be presented at relevant national and international scientific conferences and published in a peer-reviewed journal.

Strengths and limitations of this study

This is the first systematic review to analyse the evidence on the relationship between local food environments and obesity in the UK, Ireland, Australia and New Zealand and to compare the findings with the North American results of a previously conducted review.

It will incorporate price as a variable of the food environment. An additional analysis of the available foodstuff quality (healthy and unhealthy) inside food outlets will be completed.

The review will be conducted in four countries with high obesity figures.

As we cannot cover the whole European and Oceanic regions, we selected four countries to represent both continents.

INTRODUCTION

The obesity pandemic has been increasing dramatically on a global scale since 1980 [1, 2]. According to the World Health Organization (WHO), over 600 million people worldwide were obese in 2014 [2]. The increased trend has particularly affected high and upper-middle-income countries that have reached a high industrialization and urbanization level. However, a growing number of low and middle-income countries are also dealing with this pandemic alongside the additional burden of malnutrition [3-6]. While the prevalence is rising across all the population segments, the highest figures have been observed in the most disadvantaged social groups [5,6]. Obesity is

now a major global health challenge especially among those who suffer socioeconomic disparities across the globe [5,6].

This condition, regarded in some literature as a disease [7] has been described as one of the most complex health problems of modernity due to its multi-causal etiology [7,8]. Beyond individual determinants, the complex social and physical contexts in which individual behavioural decisions are made appear to strongly influence the outcome [9,10]. Based on this approach, Swinburn and Egger defined the concept of the obesogenic environment as the "sum of the influences that the surroundings, opportunities or conditions of life have on promoting obesity in individuals and populations" [11]. Understanding the environmental influences over people's eating behaviours is a major challenge for researchers because people live and function in multiple urban areas where there are many opportunities to shop and eat food throughout the day [12]. Though some studies have found a negative or null association between food environments and obesity [13,14], other studies do point to evidence that deprived food environments encourage an obesogenic food behaviour in the population living and/or working there [8,10,13,15,16]. Studies from a residential perspective have described how these environments appear to encourage an excessive energy intake and weight gain in the medium and long term, especially in those residents whose mobility is limited because of health or transport access such as the elderly and those on low-incomes, but more work needs to be done to better understand these associations and in particular if there are types of food, for example high-energy-dense foods that are featuring excessively in diets [8,10,13-16].

Local food environments include the social, macro-level and physical aspects that influence people´s food choices [17]. One factor related to the macro-level dimension and two related to the physical aspects have been highlighted as key determinants for those who purchase food within deprived neighbourhoods: price, physical access and availability to (and quality of) foodstuffs inside food sources [17,18]. Food prices, which are mainly regulated by the governments and the global market, can become major barriers for low-income populations [17,18]. Drewnowsky and other authors have identified that individuals under economic constraints, frequently shop and consume high-energy-dense foods which are generally cheaper than healthy products

[17,18]. Physical access, which refers to the distance from households to food sources, has also been identified as a barrier for economically and physically disadvantaged people. Studies have described how such people often rely on the purchase of food in nearby and walkable areas rather than spending budgets on public or private transportation to purchase food further away [13,17]. Cummins, Gibson, and Burgoine among others, have shown that many deprived urban zones have a major density and exposure of less healthy food sources, increasing the access to high-energy-dense foods [8,13,15,16,19-21]. The in-store availability, depicted as the variety of food provision within food sources, is directly related to the quality of foodstuffs people can purchase. Provision of foods is different in affluent versus deprived areas, where in the latter the offer is frequently less healthy and less varied than in wealthier areas [8, 19-21]. The intersection of these three determinants could facilitate obesogenic food purchases and food intake, leading to a steady increase in body fat over time [8,17-21].

A large volume of evidence has been generated in North America on this topic during the last decade. According to Cobb et al., in spite of many studies having found a null or negative relationship, a substantial number of other studies have shown a positive association between the aforementioned food environment variables and the prevalence of obesity among children and adults [13,17]. In the case of Europe and Oceania, there is a lack of recent analysis of the emerging evidence despite the UK, Ireland, Australia and New Zealand being among the nations with the highest figures and the worst projections of obesity in Western Europe and Oceania [4]. Two important similarities between these countries and the North American scenario also lead us to believe that a discussion of the studies assessing this relationship is necessary. In all regions the obesity prevalence is concentrated in disadvantaged urban areas, and all of them are experiencing the same post-nutritional transition with a strong influence of a globalized and industrialized food market [6,18]. Therefore this systematic review of the literature in the UK, Ireland, Australia and New Zealand is timely, alongside a comparison with the North American findings.

Eight systematic reviews and one scoping review, focusing mainly on the US and Canada have examined the associations between environment and obesity

[10,13,14,22-26]. Two analyzed the whole built environment, including transportation and physical activity access [14, 25]. Three explored the consumer retail food environments without a detailed analysis of the relationship with obesity [10,23,24]. Finally, one examined the association between the food environment and weight status and the other two the relationship with the obesity [13,22, 26]. This will be the first systematic review to explore the relationship between local food environments and obesity in UK, Ireland, Australia and New Zealand, incorporating food price [11,18] as part of the food environment. An additional analysis of each variable will be carried out considering the quality of foodstuff (healthy and unhealthy) to which people are exposed in residential zones.

Cummins and Macintyre (2006) recommend a regional analysis of the available research in other high-income countries in order to identify if the social, economic and geographic contexts are similar enough to attribute the same causes at a global scale [9,10,26]. Until now, the most consistent evidence for a "contextual" effect of food environment is only available from North America [9,13,14,26]. Furthermore, following a variety of public health and private interventions created to promote healthy lifestyle within neighbourhoods over the last decade, such as the insertion of a higher number of supermarkets in deprived areas and social media campaigns about healthy eating [27], it is important to discuss if and how this phenomenon is affecting the most vulnerable population living in these European and Oceanian countries mentioned above.

Objectives

The primary objective is to examine the evidence on the association between local food environments and obesity in the UK, Ireland, Australia and New Zealand. The secondary objectives are to identify gaps in the evidence related to this particular association and analyse the pertinence of this relationship considering the regional contexts.

METHODS

We will carry out a systematic review of the literature. We will draw on the methodology developed by Cobb et al. in 2015 who explored the relationship between local food environments and obesity in the US and Canada [13]. The proposed review will extend the geographic scope of that work by focusing on studies conducted in the UK, Ireland, Australia and New Zealand. It will maintain the physical food access and availability dimensions included in the review by Cobb et al. and will incorporate a third dimension: food price. Finally, it will be guided by The Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA - P) [28].

Eligibility criteria

Types of studies

All observational epidemiological studies that have assessed access and/or availability of food sources inside neighbourhoods (cohort, longitudinal, case - study and cross-sectional) with group level data and with individual-level data on more than 200 people will be included. It will exclude the studies with less than 200 people. This sample size –threshold was used by Cobb et al. who identified that studies with a smaller sample would be statistically underpowered for the detection of a significant association between the variables [13]. Our study will follow the same criterion as we wish to compare both reviews in a later discussion.

Participants

Eligible participants will include populations regardless of age, sex or ethnicity living in UK, Ireland, Australia and New Zealand. Studies with a separated analysis of adults and children will be included, and in the case where this information has not been provided, the authors will be contacted to request that specific data.

Years considered

The review will include studies from January 1990 through May 2017. The initial cut-point year was adopted by Cobb and other reviews, the rationale being that before the last decade of the 20th century very little data appeared in this field [11, 13, 29].

Setting

The sample will include research articles only from UK, Ireland, Australia and New Zealand.

Language

Only articles written in English will be included as English is the predominant language of the selected countries.

Exclusion criteria

Literature exclusively looking at individuals with major pathologies, pregnant women, homeless populations, breastfeeding women and participants with physical limitations will be excluded. This is because these conditions independently affect nutritional status. Individuals with obesity grade 3 will also be excluded because this is the most severe stage of obesity and according to the evidence [2,7], there are other physiological causes involved in that status (increases in morbid obesity).

Search strategy

A preliminary scan in Medline was carried out with the purpose of identifying and building a list of index and free terms (see Supplementary Appendix 1). The final list of search terms was agreed through a consultative process with the review team, clinical and social science colleagues, and a senior librarian at The University of Edinburgh. Due to the iterative nature of the search process, additional search terms and sources may be incorporated into the search strategy. The following databases will be searched: MEDLINE (Ovid), EMBASE (Ovid), Scopus, CINAHL, ASSIA and Web of Science. Grey literature will also be sought by searching Opengrey Europe (SIGLE), The Grey Literature Report, relevant government websites related to the countries included in this review (UK Foresight programme, Australian Institute of

Health and Welfare, National library of Australia, PANDORA (Australian Government Web Archive) and Obesity Policy Coalition Australia) and other international organizations' websites related to this topic (World Obesity Federation, Spotlight project and European Association of the Study of Obesity (EASO). Additionally, the reference lists of the selected articles will be checked for additional articles that can potentially be retrieved.

Study records

Data management

Retrieved studies from databases, grey literature and hand – searching will be exported to Endnote Library. The programme will also be used for the screening and deduplication process.

Selection process

Two researchers (AF and GC) will independently undertake the selection of studies, and data extraction. Discrepancies will be solved by consensus between the two authors. If required, a third party (EG) will make a judgment on the data entered and act as an arbitrator. Full text articles will be retrieved.

Data extraction

Data items were selected after a review of previous data collection strategies published in previous reviews [13, 26] and through consideration of the variables this study seeks to explore through the evidence (See Supplementary Appendix 2). Features to be extracted will include:

Authors´ names

Article description

Design: title, study design, year of study, year exposure data collected, country, city, urban/rural, age range, study exclusions, special characteristics of study population

Aims and working definitions of food environments and food outlets

Exposure and methods of data collection

Outcomes reported: outcome definition, self-reported or measured

Statistical analysis

Key findings

Limitations

Data from each study will be collated into the form, and a final database of all forms will be elaborated using a customised Excel sheet. The extraction form will be piloted before its full use in the review. During the pilot, the first ten articles will be independently extracted and jointly reviewed by the two reviewers. The remaining articles will be extracted by one reviewer and reviewed for accuracy by the other.

Outcomes and prioritisation

The primary outcome is obesity. The diagnosis of this pathology follows the criterion established by the World Health Organisation to classify the obesity with a Body Mass Index (BMI) over 30 kg/m² [2]. Change in BMI, as well as measurements of weight and height will be used to calculate and classify the nutritional status.

The secondary outcome is central obesity, represented by waist circumference and waist to hip ratio (only if the primary outcome is not included).

Risk of bias in individual studies

All the selected studies will be assessed using The Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies [30]. This checklist is a useful tool to develop a critical appraisal of these type of studies. The items contained are:

Research question

Study population

Sample size

Data synthesis

A separate narrative synthesis and a summary of the results for children and adults will be performed, according to the type of food exposure-outcome. The measurement techniques chosen in every study will also be analysed. Finally, this will be compared with the main findings generated in the original North American systematic review.

Subgroups analysis: men, women, adults, children, low SES, high SES, urban, rural and by country.

Protocol registration

A detailed protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO): 2017:CRD42017068193 (http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42017068193). The study will be guided by the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols (PRISMA-P) 2015 statement [28].

Conclusions

Previous systematic reviews have assessed the evidence related to the association between local food environments and obesity in the US and Canada [13,26]. This systematic review is the first study that will geographically extend the work undertaken by Cobb et al., analysing the relationship on evidence from the UK, Ireland, Australia and New Zealand. Furthermore, it will incorporate food price as part of the food environment and develop an additional analysis of the quality of foodstuff (healthy and unhealthy) available inside the residential areas measured. Finally, it will undertake a comparative analysis by country and between the regional results and the North American findings. This is highly relevant in order to gain a better understanding of whether the phenomenon is subject to regional variations or if it is occurring on a global scale.

ETHICS AND DISSEMINATION

As this is a review of published literature ethics approval has not been sought. However, this work is subject to Institutional Review Board oversight by The University of Edinburgh's Centre for Population Health Sciences. The review findings will be presented in relevant national and international scientific conferences and be published in a peer-reviewed journal.

Competing interests

None declared.

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Contributors

Andrea Fuentes conceived the idea for this work and drafted the protocol. The draft was critically revised according to several rounds of critical comments by Daryll Archibald, Liz Grant and Valeria Skafida and Gabriela Carrillo. All the authors will be involved in the systematic review process.

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Appendix 2 List of search terms

Supplementary APPENDIX

Search strategy developed for MEDLINE (OVID)

1. Food environment*.tw
2. Fodscape*.tw
3. Food access.tw
4. Food availability.tw
5. Food affordability.tw
6. Food outlet access.tw
7. Food price.tw
8. Food store*.tw
9. Food outlet*.tw
10. Grocer*.tw
11. Convenience store*.tw
12. Supermarket*.tw
13. Restaurant*.tw
14. Food bank*.tw
15. Online shopping.tw
16. Food shopping.tw
17. Economic access.tw
18. Residential.tw
19. Neighbo*.tw
20. Neighbourhood.tw
21. Urban area*.tw
22. Obes*.tw
23. Obesogenic.tw
24. Overnutrition/
25. Overnutrition.tw
26. Over nutrition.tw
27. Overweight/
28. Body Mass Index/

29. BMI.tw
30. Weight adj2 change.tw.
31. Weight status.tw
32. Weight control.tw
33. Waist circumference.tw
34. OR/1-21
35. OR/22-33
36. 34 AND 35

Appendix 3 The Geo-Fern checklist

Geo-FERN (Geographic Information System Food Environment ReportiNg) Checklist		
INSTRUCTIONS		
For each reporting item, insert a tick or cross in the shaded box to indicate whether the item has been reported, or insert 'N/A' if not applicable. Shading indicates whether items are essential or desirable. Reporting items can be included in supplementary materials if word limits are tight and if allowed by the publisher.		
FOOD OUTLET DATA	Essential	Desirable
Name of the data creator (e.g. 'Yellow Pages',		
Collection and/or publication year of the data		
Title of the dataset.		
Digital identifier of the dataset (e.g. a web address		
Publisher of the dataset.		
Scope of the dataset (i.e. the geographic coverage of the dataset e.g. 'national' or 'regional' and the range of businesses included in the dataset, including any notable exclusions).		
Identification of the data fields used in analyses.		
Original purpose of the data (e.g. food hygiene regulation enforcement or commercial business data).		
Methods used by the data creator to collect the data/compile the dataset (e.g. audits conducted by data creator).		
Prevalence of missing data (e.g. number of entries with incomplete address information).		
Methods for handling missing data (e.g. case-wise deletion, or use of secondary sources to impute missing data).		
Information on the accuracy of the data e.g. via reference to one or more validation studies or acknowledgement that data accuracy is unknown.		
EXTRACTING FOOD OUTLETS	Essential	Desirable
Description of methods used to extract food outlets of interest from dataset (e.g. search for specific proprietary classifications or store names).		
If outlets were extracted using search terms (e.g. proprietary classifications or store names): An exhaustive list of search terms (where proprietary classifications are used, it should be made explicitly clear that the classifications listed are those of the data provider).		

If outlets were extracted based on proprietary classifications: A copy of the proprietary classification scheme, optionally including exemplary outlets falling within each classification; OR, A discussion of any notable categories excluded from analyses (e.g. pubs, pharmacies, mobile food vendors etc.).		
DEFINING FOOD OUTLET CONSTRUCTS	Essential	Desirable
Construct name(s) (e.g. 'supermarkets', 'healthy outlets', 'convenience stores' etc.).		
Description of the methods used to group outlets into constructs, including at least one of: An *exhaustive* list of any list-based criteria used to define each construct. This could include e.g. proprietary classifications making up each construct, or a list of store names making up each construct. Where proprietary classifications are used, it should be made explicitly clear that the classifications listed are those of the data provider. Any objective criteria e.g. floor space, number of tills etc. used to define constructs. Citation of any previously published categorisation schemes that have been applied to the data and description of the methods used to apply the scheme. Description of any other methods used (note methods based on subjective criteria are discouraged).		
Examples of outlets falling within each construct such that the scope of each construct can be more readily interpreted. For example, if the construct 'fast food outlet' includes 'traditional' burger and		
Identification of any additional data sources used to group outlets into constructs e.g. use of Google		
Description of how any additional data sources were linked to the food outlet data (e.g. by matching store names and/or addresses).		
Where proprietary classifications are used to define constructs, a copy of the entire proprietary		
GEOCODING METHODS	Essential	Desirable
Acknowledgement of whether any data has been geocoded.		
The address model used (e.g. areal unit, street segment, land parcel, address point).		
The match rate achieved.		

The environmental context, including details on how this was defined e.g. the study area was urban/rural, defined based on population density.		
Geocoding software used, including the version number.		
The source of geocoding reference data (e.g. street line segment data), including publication date.		
ACCESS METRICS	Essential	Desirable
Definition of the conceptual environment being measured e.g. home, school, work etc.		
Intensity Metrics		
If areal zoning system used: The type of areal zoning system (e.g. government districts, census tracts etc.) The source of boundary data, including the publication date or other version identifier.		
If buffer zoning system used: The buffer size. The type of distance measure (e.g. Euclidian or network).		
The units of the intensity metric(s) (e.g. count per unit area, as measured in meters) or formula indicating how they were calculated.		
If network data was used (i.e. to calculate network distances): The source and publication date of network data. The types of road/path included.		
Rationale for the choice of zone type (e.g. areal vs buffer) and/or size as applicable.		
Proximity Metrics		
The type of distance measure (Euclidian vs network).		
If network data was used (i.e. to calculate network distances): The source and publication date of network data. The types of road/path included.		
Gravity Metrics		
The zone radius.		
The decay coefficient.		
UNKNOWN DETAILS	Essential	Desirable
Any items noted as essential, but that are unknown should be highlighted as a limitation.		

Source: Wilkins, E., Morris, M., Duncan, R. & Griffiths, C. (2016) Using Geographic Information Systems to measure retail food environments: discussion of methodological considerations and a proposed reporting checklist (Geo-FERN). **Health & Place**.

Appendix 4 Base map data and procedures

The collection of the food sources data needed to map and analyse the foodscape required the search of different printed and digital sources and a field and online data validation process.

Map data and foodscape boundaries

The data files were provided as a ZIP folder and contained the following products: OS VectorMap® Local, OS MasterMap Greenspace, Code-Point®, Code-Point® with Polygons, OS Open Names, Points of Interest and Boundary-Line™. As follows, the table 1 displays the name and main data that every file contains.

Table 13. Ordnance Survey dataset features

Name of the file	Dataset description	Downloaded version
OS VectorMap® Local	The base map is composed by 12 files that build one master layer: ns 55 ne, ns 55 nw, ns 56 ne, ns 56nw, ns 56 se, ns 56 sw, ns 65 ne, ns 65 nw, ns 66 ne, ns 66 nw, ns 66 se and ns 66 sw. It includes local details including roads, railways, vegetation, boundaries, buildings and contours. It was adjusted to the British Coordinate Reference System (CRS) EPSG 27700.	January 2018
OS MasterMap Greenspace	The layer is composed by 9 files: ns5055, ns6560, ns6565, ns6060, ns6055, ns5565, ns5560, ns6065, ns6555. It contains the greenspace sites, such as parks and sports facilities. This includes allotments or Community Growing Spaces, bowling Green, cemetery, religious grounds, golf course, other Sports Facility, play Space, playing Field, public Park or Garden and tennis Court.	October 2017
Code-Point® with Polygons	It contains the postcodes units with their geographical boundaries. They are derived from ADDRESS-POINT®, an Ordnance Survey product that provides a National Grid co-ordinate for each postal delivery address in Great Britain. Each postcode unit boundary is created to surround all addresses with the same postcode. Mainly to a 0.1 metre resolution.	January 2018

Code-Point®	This file includes a list of all the current postcode units in Great Britain including coordinates. Multiple postcodes in a single block of flats or offices will share one National Grid reference.	February 2018
OS Open Names	This file lists definitive place names, roads numbers and postcodes in Great Britain.	January 2018
Points of Interest	Dataset containing around 4 million different geographic features. All features are supplied with location, functional information and addresses where possible. The product covers all of Great Britain.	March 2018
OS MasterMap® Integrated Transport Network™ (ITN) Layer	This layer consists of a fully topologically structured link-and-node network representing the Roads Network of Great Britain, from motorways to pedestrianised streets. The dataset contains road classifications; road names; forms of road; motorway junctions; information potentially relevant to routing; and references to the intersecting polygons from OS MasterMap Topography Layer.	July 2018

Appendix 5 Procedure to extract food sources postcodes in QGIS

To find food sources postcodes I examined two Digimap layers: Code-Point® and Code-Point® with Polygons. This layer shapes the spatial limits of each postcode area (polygon) in Great Britain. These areas normally contain a group of houses and/or buildings in a block.

The shape file also provides the option to visualise the postcode number and the centre of each polygon. Once Glasgow postcodes were visible, the next task was to explore different ways to extract the foodscape postcodes data.

To do this I used the following commands:

Menu → Vector → Geoprocessing tools → Intersection → Select Input later → Select Intersect later → Name Output later →OK

After the intersection, I saved a new layer with the foodscape postcodes. Using the QGIS tool “counts points in polygon”, I identified a list of 787 postcodes. I extracted these from the layer attributable table and saved the data in a new Excel file. Then, I proceeded to identify the postcodes of the neighbourhood and the buffer separately. This enabled me to differentiate the addresses within each area and the later neighbourhood and buffer food sources geolocalisation. Following the same procedure used to identify the foodscape postcodes, I intersected both areas and saved these two new layers. I extracted again the postcodes of each zone in different Excel files to back up the datasets.

After which I found 591 postcodes in the buffer and 196 in the neighbourhood. The extracted datasets included the postcode in consecutive order and their respective coordinates among other geographic information. As a way to ensure I had the complete dataset of each zone, I verified the inclusion of each postcode within the foodscape using the tool “”select features by area or a single click”. This enabled me to click on the code-point (point representing spatially the postcode) and crosscheck its description in the respective

attributable table. The final list of postcodes included the districts G31, G32, G33, G40 and G73 and 787 full postcodes

Appendix 6 FSS classification

Annex B: Food Hygiene and Food Standards categories of establishments

INSPECTIONS LIABLE USE — PREMISES USE

FSA monitoring category ➢ Minimum data requirement	Definitions of establishments/Examples
Primary producers ➢ **Primary producer** At Inspections Liabilities Food Main Use "PRIMAR" FO1	Examples: Farm Shop — FRMSHO • Fruit and vegetable growers — FRMBEA • Pick your own farms — FRMFAV • Egg producers — FRMPYO • Potato growers — FRMPOT — FRMEGG • Fish farms — FRMOTH • Beekeepers — FRMFIS • Vineyards — FRMBEE • Dairy Farm — FRMVIN FRMDAI
Manufacturers & packers ➢ **Manufacturers & packers** At Inspections Liabilities Food Main Use MAFPAC FO2	Examples: Oil + Fat Processing — MANOIL • Abattoirs — ABATTO • Brewery/Distillery — MANDIS • Meat manufacturers — MANMEA / MANBUR/MANPOU • Milk processors & dairy processors — MANMIL/MILK/MANICE • Cheesemakers — MANCHE — MANFCO/PACCHE/MANOTH • Soft drinks, mineral waters — MANDRI • Vegetable drying, freezing, canning — MANVEG • Meat or poultry cutting establishments — MANMAP • Purification centres for shellfish — MANSHE • Fish processors — MANFIS • Butchers shops cooking hams — MANBUR • Fruit & vegetable co-operatives — PACFAV • Egg packers — PACEGG • Contract packers — PACOTH • Food contact material and article manufacturers & suppliers — FOOCON • Bakers with no on-site retail — MANBAR • Bakeries selling through their own shops — MANBAK • Home cake makers selling to other businesses — MANRET • Chocolate/confectionery — MANCHO
Importers/Exporters ➢ **Importers/ Exporters** IMPBRD IMPEU FO3	Examples: • Warehouses for import/export purposes — IMPDOC • Freight depots, transit sheds, stores — IMPOTH
Distributors/ Transporters ➢ **Distributors/ Transporters** DISTRI FO5	Examples: • Food brokers — DISFRU • Wholesalers — DISGRA • Cash & carries — DISWHO • Cold stores — DISCAC • Haulage companies — DISCOL • Milk distributors — DISHAU/DISVEH MILK DISPOT

FSA monitoring category ➢ Minimum data requirement	Definitions of establishments/Examples
Retailer ➢ **Supermarket/ Hypermarket** SUPMAR FOGA	Supermarkets e.g. Sainsbury, Tesco, Asda, Morrison, Co-op, Marks and Spencer, Waitrose, Aldi, Lidl, Budgens etc. that provide a range of food items from more than one grocery sector and from a range of brands. Also city centre or local variants of larger supermarket groups, e.g. Sainsbury's local, Tesco Metro, Tesco Express etc.
	Examples: RETFRO RETFOO • Supermarkets - the large retail chains • City centre or local variants of larger supermarket groups
Retailer ➢ **Smaller retailers** RETAIL FOGB	Smaller-scale food businesses such as butchers, bakers, fishmongers, village shops, grocers etc. Independent retailers e.g. Costcutter, One-Stop, Londis, Nisa, Premier etc.
	Examples: • Grocers RETGEN • Confectioners RETNEW • Butchers (retail only) NONBUT/RETBUT • Fishmongers RETFIS • Greengrocer/fruiterer RETFAV • Health food shops RETHEA • Bakers shops (retail only) NONBAK/RETBAK • Newsagents RETNEW • Mobile vans (retailers) MOBAK/MOBBUT/MOBFIS/MOBFOO/ MOBICE • Market stalls (retailers) MKTFOO • Farm shops (if farm not included under producers or other establishments) • Off licences RETOFF • Garage minimarkets RETOTH
Retailer ➢ **Retailers - Others** RETOTH FOGC	Retail establishments which do not fit into one of the other retailer categories, e.g. establishments that primarily sell non-food products and a very limited range of food products.
	Examples: RETCHE • Shops where the main business is not food, e.g. chemist/pharmacy that sell cough sweets/limited range of other confectionery
Restaurant & Caterers ➢ **Restaurant/Café**	Establishments whose primary business is to cook/prepare food for consumption by customers at a seated area on the premises.

FSA monitoring category ➢ Minimum data requirement	Definitions of establishments/Examples
/Canteen RESTCA FO1A	Examples: • Football Stadium CATFST • Restaurants CATRES • Cafes CATCAF • Self-service cater • 'Fast food' establishments providing seating, e.g. McDonalds, Burger King etc. The drive-thru variants of these chains should also be included in this category. • CANTEEN CATCAN CATGOV
Restaurant & Caterers ➢ **Hotel/Guest House** HOTEL FO1B	Establishments that provide catering only to customers to whom they are also providing accommodation. (Hotels that provide a restaurant service to a wider clientele than their guests should be recorded under the 'restaurant/café/canteen' category).
	Examples: • Hotels CATHOT • Guest houses CATB • Bed and breakfast CATB • Hostel CATHOL
Restaurant & Caterers ➢ **Pub/Club** PUBCLB FO1C	Commercial establishments that primarily serve alcohol in a public bar. If the establishment has a separate restaurant facility it should be recorded under the pub category.
	• Public Houses RETPUB CATPUB • Night clubs/clubs with bars CATCLB CATDIS
Restaurant & Caterers ➢ **Take-away** TAKAW FO1D	Establishments that provide convenience food to customers, primarily for consumption off the premises. Establishments must be immobile and housed in a designated building.
	Examples: • Fish & chip shops • Take-away CATTAK • Sandwich shops • Establishments that prepare and deliver convenience food directly to the customer
Restaurant & Caterers ➢ **Caring Establishments** CARING FO1E	Establishments with catering services for clients/customers who are provided with care, medical treatment, supervision, or assistance.
	Examples: • Hospitals (include each establishment but not each kitchen) CATHOS • Nursing/care homes CATNUR • Childcare facilities/nurseries/childminders CATDAY • Prison CATPRI
Restaurant & Caterers ➢ **School/College** SCHOOL FO1F	Catering services located within a site providing educational instruction and formal qualifications.
	Examples:

FSA monitoring category ➢ Minimum data requirement	Definitions of establishments/Examples
	• Colleges • Schools (include each establishment but not each kitchen) CATINE CATSCH CATSEC
Restaurant & Caterers ➢ **Mobile food unit** MOBILE FOTG	A food establishment that comprises a kitchen or catering facility operating from a mobile unit such as a vehicle, trailer, stall, marquee or other non-permanent structure.
	Examples: • Mobile catering units CATMKT CATMOB • Burger vans and other fast food vans/trailers/stalls MKTFOO
Restaurant & Caterers ➢ **Restaurants and caterers - Other** RESTUR FOTH	Restaurant/catering establishments that do not fit into one of the other 'restaurants and caterers' categories.
	Examples: • Home caterers such as cake makers selling directly to consumers CATHOM CATTEA • Village halls, community centres etc. used by charitable/community organisations, see www.food.gov.uk/enforcement/enforcework/food-law/guidance-enforcement/community-hall-guidance CATCOM CATKIT • Ships' catering spaces CATOTH CATSHI

Appendix 7 List of subcategories

Code	Type of outlet	Description
1. Restaurant, Pub & Hotel Restaurant		
1.1	Traditional	Sit down restaurant
		Waiter/waitress takes your order
		Pay for meal after eating
1.2	Buffet	Sit down restaurant
		No waiter service
		May pay at the till after food has been selected from the buffet but before eating
		If 'all you can eat' at a fixed price may pay before or after consumption. Drinks may or may not be included in the price.
1.3	Restaurant with takeaway/delivery option	Primarily a restaurant but has the option to order for takeout
		Waitress/ waiter service or Food is ordered and paid for at the counter and eaten elsewhere
		Usually open after 5pm
		Examples include Chinese restaurants, Indian restaurants, pizza hut
1.4	Fast Casual (e.g. Nandos)	Order and pay for food at counter
		Waitress/ waiter delivers food to table
		Similar to fast food but offers a higher quality of food and atmosphere
		Usually sit down but may have takeaway option
1.5	Pub Sit down restaurant	Sells predominantly alcohol
		Sit down restaurant
		Waiter/waitress takes your order
		Pay for meal after eating
1.6	Pub Fast casual	Sells predominantly alcohol
		Order and pay for food at bar. Waitress/ waiter delivers food to table
		Similar to fast food but offers a higher quality of food and atmosphere
		Sit down only not takeaway
1.7	Pub with takeaway/delivery option	Primarily a pub but has the option to order for takeout
		Waitress/ waiter service or food is ordered and paid for at the counter and eaten elsewhere
1.8	Traditional Hotel	Restaurant with waiter service
		Light bar meals with/without waiter service
		Room service and banqueting rooms
		May have a buffet for selected meals (e.g. breakfast)

2. Pub no food		
2.1	**Pub no food**	Only alcoholic and non- alcoholic drinks served.
		May served crisps and nuts behind the bar
		Includes nightclubs
3. Sit In café/coffee, specialist and sandwich shop		
3.1	Traditional café	Predominantly coffee and hot beverages sold
		Informal seating area
		May have waiter service or order at the counter
		Pre-made/made to order sandwiches and confectionery available
3.2	Greasy spoon types cafe	Predominately less healthy fried foods
		Informal seating area
		May have waiter service or order at the counter
3.3	Specialist café	Includes milkshake/smoothie bars and ice cream shops
		Similar in style to cafes and coffee shops
		Informal seating area
		Fair trade cafes/coffee shops are included here
3.4	Café with delicatessen/bakery	Predominantly café with delicatessen/bakery counter enabling ready-to-eat foods to be taken away
		Informal seating area
3.5	Sit-in sandwich shop	Small seating area
		Order and pay at the counter
		Made to order sandwiches/salads etc. May sell drinks, branded snacks and homemade cakes
		No waiter service
		Sit down or takeaway

4. Takeaway café/coffee, specialist and sandwich shop		
4.1	Takeaway café	Predominantly coffee and hot beverages sold
		No seating - takeaway only
		Pre-made/made to order sandwiches and confectionery available
4.2	Greasy spoon types cafe	Predominately less healthy fried foods
		No seating - takeaway only
4.3	Specialist café	Includes milkshake/smoothie bars and ice cream shops
		Similar in style to cafes and coffee shops
		Takeaway only
		Fair trade cafes/coffee shops are included here
4.4	Traditional sandwich shop	Made to order sandwiches/salads etc.
		May sell drinks, branded snacks and homemade cakes
		No sit in option - takeaway only
5. Baker - Retail		
5.1	Baker - Retail	Freshly baked savouries/bread, pre-made sandwiches, baked sweet products and branded products
		Usually a chain e.g. Greggs, Milligan's, Bakers Oven but can be independent
6. Takeaway and Fast Food		
6.1	Traditional takeaway	Hot food ordered and paid for at the till
		Wait whilst food is prepared and cooked
		No sit down option to eat-in but may have a seated waiting area.
		Usually open after 5pm
6.2	Traditional takeaway + delivery/collection	As traditional plus: The option to telephone for delivery and/or collection
6.3	Traditional takeaway + delivery/collection	As traditional plus: Limited seating is available giving the option to eat-in
	With seating	May have the option to telephone for delivery and/or collection
6.4	Instant fast food	Food ordered and paid for at the till
		Available instantly as commonly cooked in bulk in advance and kept hot. Food that can be eaten without cutlery
		Sit down, takeaway and drive-thru facilities
		May be part of a chain or franchise

7. Supermarket		
7.1	Large multiple	Large, departmentalised, self-service food store selling food and household goods
		E.g. Tesco, Asda, Morrisons, Sainsburys
7.2	Discount	E.g. Kwiksave, Netto, Lidl, Aldi
7.3	Small multiple	Smaller, self-service food store selling a limited range of food and household goods for greater convenience
		E.g. Tesco metro/express, large Nisa/Premier
8. Convenience		
8.1	Traditional (corner shop)	Sells groceries, newspapers/magazines, snacks, drinks, lottery, tobacco products and sometimes pre-packed sandwiches
		Small and usually independently owned
		Usually have extended hours
		Usually found in more residential areas
8.2	Newsagents	Small in size
		Sells primarily newspapers, magazines, snacks, drinks and tobacco products
		In well-trafficked public places
8.3	Petrol Station Shop	Sells groceries, newspapers/magazines, snacks, drinks, lottery, tobacco products and sometimes pre-packed sandwiches
		Usually have extended hours
		May be a small multiple supermarket
8.4	Off-licence	Licensed to sell alcoholic beverages for consumption off the premises
		Also sells groceries, newspapers, magazines, snacks, drinks and tobacco products.
9. Specialist (Purchase to takeaway only)		
9.1	Organic food stores	
9.2	Health food stores	Health supplements
		No fresh foods
9.3	Fair Trade stores	
9.4	Seasonal/ farmers market	Includes farmers markets and seasonal markets such as Christmas fayres
9.5	Artisan Food Stores	Stores selling only locally produced goods
9.6	Delicatessen	Grocery type store.
		Sells fresh ready-to-eat foods (made to order sandwiches/salads, cooked meats and cheeses etc.)
9.7	Wine Merchant	E.g. Majestic, Oddbins
9.8	World food (All sizes)	E.g. Oriental, Indian and Continental shops and supermarkets
9.9	Candy/sweet/ chocolate shops	Shops that do not fall under the category of convenience or confectioners as sell only bought in sweets
9.10	Butcher	Fresh meat is prepared and sold in store
9.11	Baker	Bread and baked products prepared fresh and sold in store
		Usually independent bakeries
9.12	Fishmonger	Fresh fish is prepared and sold in store
9.13	Greengrocer	Sells fresh fruit and vegetables
9.14	Dry goods only/Weigh house	Dry good only, usually sold by weight

10. Mobile food and market*		
10.1	Food provision	Food to take home
		Usually needs preparation before consumption
		e.g. meat stall at a farmers market
10.2	Takeaway food	Food to consume now
		Usually found at outdoor events e.g. music festivals, food matches, outside nightclubs
		Includes burger vans, noodle stands, breakfast bars etc.
10.3	Ice cream van	
10.4	Beverages	Includes coffee carts and smoothie stands

*Saturday/farmers markets. For static markets, individual stalls should be classified under 'specialist' categories.

11. Vending machines (Stand alone. Not a part of another food outlet)		
11.1	Hot beverages	Vending machine contains hot drinks.
11.2	Cold beverages	Vending machine contains cold drinks.
11.3	Food	Vending machine contains food e.g. confectionary, savoury snacks, sandwiches.
12. Non-food stores (Includes crisps and confectionery usually displayed around the till area common around Christmas, Easter, Halloween etc.)		
12.1	Clothes/accessory shops	
12.2	Gift shops	
12.3	Stationery shops (WH Smith)	
12.4	Furniture/catalogue shops	
12.5	Sports Shops	
12.6	Cosmetic/toiletry shops	
12.7	Pharmacy	Retail shop where medicine and other health and beauty items are sold.
		Snack foods and confectionery may be available
		Particular stores may have lunch meal deals (e.g. Boots)
12.8	Hardware store e.g. B&Q	
12.9	Post Office	
12.10	Department Stores	Large retail store organized into departments offering a variety of merchandise; commonly part of a retail chain
		Usually contain a restaurant/café selling hot and cold foods and/or a food hall.
12.11	Large Discount store (e.g. Wilkinsons, TJ Hughes)	Meet the requirements of a department store but have lower cost structures and typically sell at lower prices. Usually contain a restaurant/café selling hot and cold foods.
12.12	Small Discount store (e.g. Poundland)	Sell novelty items/clothing and low price branded food items (not fresh)

13. Entertainment (Primarily visit establishment for entertainment - food is secondary to this)		
13.1	DVD/Video/Games rental shop	Primarily snack foods and drinks. Some hot snacks occasionally sold (i.e. Blockbuster video)
13.2	Cinema	Primarily snack foods and drinks. Some hot snacks occasionally sold.
		Popcorn, ice cream, sweets - pre-packed and pick and mix, crisps, cold drinks, hot dogs etc.
13.3	Theatre	Primarily snack foods and drinks, alcohol sold. Sometimes includes a restaurant.
13.4	Casino	May include a sit down restaurant and/or provide bar snacks. Licensed to sell alcohol.
13.5	Comedy Clubs	May include sit-down restaurant or offer bar snacks
		Usually licenced
13.6	Music venues/music bars (Jazz Club)	May include sit-down restaurant or offer bar snacks. Usually licenced
13.7	Amusements	Snack foods and drinks. May have café and may be licensed.
		E.g. Noble
13.8	Ten-pin bowling	Snack foods and drinks. Usually licensed.
		Commonly a restaurant/diner selling meals
13.9	Snooker/Pool clubs	Hot/cold snacks may be available. Usually licenced
13.10	Sports related (football match/golf club)	Hot/cold snack food and confectionery bought to takeaway. Usually licenced
13.11	Art Gallery	Primarily snack foods and drinks, alcohol sold. Sometimes includes a restaurant.
13.12	Motor sports/Karting	Primarily snack foods and drinks.
13.13	Library	Primarily snack foods and drinks. May have café.
14. Health and Leisure		
14.1	Gyms	Equipped for sports or physical training
		May include vending machines or small café
14.2	Health Clubs	Usually has additional facilities to a gym.
		May include vending machines or small café/restaurant
14.3	Leisure Centre	Usually owned and run by the council - similar facilities to a health club
		May include vending machines or small café
14.4	Climbing centre	Indoor or outdoor climbing facilities
		May include vending machines or small café/restaurant
14.5	Soft Play	May include vending machines or small café/restaurant

15. Closed/Private food outlets (Not accessible to the public (e.g. offices and universities))		
15.1	Clubs and Associations	Usually snack food and drinks
		Working men's clubs, coffee mornings etc.
		May be licensed
15.2	Function rooms	A venue used for weddings, receptions & parties
		Usually licensed
15.3	Community centres	
15.4	Charitable organisations	
15.5	Hospitals	
15.6	Staff canteens	No waiter service
		Food is paid for at the till before consumption
		Usually hot meals and pre-packed/made to order sandwiches and salads
		May include vending machines
		Includes staff rooms
15.7	Education/Childcare/Care for elderly	No waiter service
		Food is paid for at a till before consumption or is paid in advance by parents/carers
		Usually hot meals and pre-packed sandwiches and salads
		May include vending machines
15.8	Wholesalers	
15.9	Suppliers	
15.10	Distribution	
15.11	Caterers	
15.12	Cash and carry	
15.13	Factory	

PROMPT – When classifying multi-use outlets: 1. What does the outside of the outlet look like? 2. What is the dominant floor space usage?

© Lake, A. A., T. Burgoine, et al. (2010). "The foodscape: Classification and field validation of secondary data sources." Health & Place 16(4): 666-673.

Appendix 8 Pre-fieldwork Field Validation Plan –

Direct observations will be conducted to record and classify the food sources within the foodscape. The area covers the neighbourhood and 1-mile buffer Euclidian perimeter, representing 7.876 km2 in total. The fieldwork will be conducted during August 2018 from Thursday to Sunday at normal business opening hours (8 am – 19 pm), with the exception of surroundings of The Celtic Park Stadium which will be carried out during days when football matched are being played from approximately 14:30 pm. During this period, the data collector (principal researcher) will validate 370 identified food sources on foot, using a planned walking route through the neighbourhood, including the hospital, cinema, stadiums, The Forge Shopping Centre, The Forge Market and any other public and open establishments selling and/or offering food (1). New food sources data will also be registered, and, in the case of private outlets, the information will be checked online and outside the establishment) (1,6). The validation will include the corroboration of the food sources data (names, addresses, coordinates, opening times and days and outlet type) (1). Additionally, a photograph will be taken complementary to the data register (6) applying a printed survey sheet (see Appendix 1). A list of the different categories and their main characteristics will be available to corroborate or change the type of establishment classification. A printed list of the 370 food sources and a set of maps of the study area will guide the exploration to cross-checked any closures, name changes or the new establishment's openings (3) The set will be produced using EDINA Digimap and will use an address point model which will divide the foodscape into a number of blocks and street segments to cover during each visit with the purpose to match food sources addresses and transform them to individual point data which is typically located at the centroid of the property/building to which the address corresponds change the textual quote (4,5). In case any street/segment did not appear on the map, Google Maps will be used to corroborate the location and also the foodscape boundary (3). Using the address point model combined with the use of google to cross-check the match will provide the study with higher spatial accuracy (3,4,5).

After the fieldwork, a consensus meeting will be held with two researchers to agree in the case there are questions/disagreements about the type of food sources. Except for the establishments mentioned above, the rest of the establishments will be classified and validated based on characteristics observed from the outside and at the entrance of each establishment. Size of the facility, items sold, type of service provided, and posted menus (restaurants only) guided the selection of outlet type (1).

Training will be conducted which includes a pilot of the survey sheet in The Celtic Park surroundings and The Forge Complex (Shopping Centre and the Market), using the GPS device and the maps of the Celtic Park and The Forge Complex area. It will consist of corroborating the identified food sources as street vendors around the Stadium (public open entrance area, the nearby streets during an event, with descriptions of the route and the outlets within the Shopping Centre and the Market and their surroundings. The route started in the intersection of two streets B Street and G Street (the intersection before entering the foodscape edge) which is the main street used to reach the Stadium. The route will be covered by foot checking all the entrances areas, surrounding blocks and the car parking zones) in the Stadium and the Forge. For each localized food source, a survey sheet will be completed and a GPS measure registered. Every GPS measure will be registered as a waypoint with a registration number, the altitude, and name the others measures. To capture the measure the data collector will work as a mystery shopper approaching less to the frontal edge of each mobile vendor to improve the spatial accuracy. The plan recognises that it may not be possible to measure within The Forge as it is a closed establishment and GPS needs to be in contact with satellites in the sky to take the measures. In the Forge a manual map was drawn, and the list of identified food sources was observed and manually recorded. Only in the Stadium will it be possible to take photos of the food sources. No tracking or photography will be taken in the Shopping centre or the market permissions as they are private enterprises. All annotations will be discretely recorded so as not to create undue attention

As certain places in the region are potentially used for multiple purposes care was taken to access, especially those which were private clubs. Within the market, the route considered to walk will be through the grid of vendors in order to register on the map the approximate locations of the food source.

Within the shopping centre, two levels will be covered, and a printed map of the approximated location recorded. Any of the spaces which are not accurately identified will be marked as such. Only the interior side of the street in case of the boundary streets will be examined, the food sources that have signs but are determined to be permanently closed will be checked and any closed store will be revisited once to corroborate if it is still active/open) (2,3)

Classification

The classification will be drawn on the Glasgow Council and Food standards classification and the previous literature that has classified food sources to categorize them according to their characteristics based on the collected data by field workers from the inside of the outlets/sources to classify food stores (2).

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Appendix 9 Survey sheet

N° ____ GPS N° ____

Date ___ / ___ / ___ Time ___:___

Open: Yes/ No

Photo: Yes/ No If the answer is no, register again:

Date ___ / ___ / ___ Time ___:___ Open: Yes/ No Photo: Yes/ No

Food sources data	Previous information	Field Validation
ID/Code		
Name		
Address and postcode		
Food source N° & category*		N° ___
Food source N° & subcategory*		N° ___
Opening times		
Opening days		

*Use the food outlet classification system (Appendix 1) to code the food source type (number)

Menu:	Chips	Fish
Chicken	Curry	Burger
Cheeseburger	Hot dogs	Sausages
Rolls/wraps	Chip & cheese	Pizza
Soup	Ice – cream	Pastries
Sandwiches	Nachos	Hot/Cold Drinks

Others:

_____
_____
_____

Category/subcategory description criteria: (size, sit-in and/or takeaway, cuisine type, available menu (healthier options), staff.

_____
_____
_____

Appendix 10 Jittering procedures

Though Excel and other statistical packages have the functionality for jittering data, I used QGIS which has a pliable tool to effectively do this, directly on layers. This software was able to scatter the points through a function called “point displacement” and permits small distance separation between the points predetermined in 1.5 meters (17). However, after various attempts I decided to double the distance to 3 meters, because of challenges in the visible separation with the established distance. Additional challenges faced included having to create Excel files for each set of repeated points as the programme scattered them by data set and not by different groups within the file. Each Excel was saved separately using csv format to facilitate their transformation to a shapefile once was uploaded into the QGIS. I uploaded files individually and created a temporary layer with an abbreviation for each set. After that, I used the following commands to “jitter” the points:

Menu → Processing → Vector geometry tools → Points displacement → Input layer → Choose repeated set layer → Displacement distance → 3 m → Name displacement points layer →OK

I was able to choose between moving the points vertically, horizontally or circular, depending on the shape of the streets or the establishments.

I distributed the jitter points in concordance to the street sides. Only in the case of the Forge Shopping Centre and The Forge Market, did I choose to spread them in a circular way. In this way, all the food outlets were fitted within the establishment. After spacing all the repeated locations, I merged the layers into one, as a backup extracted the new coordinates, and added to the foodscape database.

To set up the final food sources layer, I chose to work with only one file instead of merging the scattered coordinates’ layer with the file containing the rest of the dataset. With the foodscape database in an Excel file, containing only the

names of the food sources and their coordinates, I uploaded and saved it as the food sources layer in a shapefile format. Once the layer was opened, the software read the locations and mapped the foodscape for the first time. As is described in Geo-Fern guidelines, this process has been defined as “geocoding” where a software converting coordinates in spatially coded reference data, in this case points in the map layer (3). To ensure all the coordinates were visualized, I counted the points using the tool “count points in a polygon”. I revised the attributable table of the new layer to observe it was incorporated the same data than the Excel file.

Appendix 11 Procedures to calculate the mRFEI

The modified Retail Food Environment Index calculation (mRFEI)

I calculated an additional measure for the purpose of assessing the healthy and unhealthy offer of the food environment: this is known as the modified Retail Food Environment Index (mRFEI). The indicator was launched in 2011 by the Center for Disease Control (CDC)'s division of Nutrition (154). mRFEI is a ratio of healthy and less healthy food retailers within census tracts across each state. Food retailers are defined by typical food offerings in specific types of retail stores (154).

The healthy food retailers' category includes supermarkets, large or traditional convenience stores, supercentres, and produce stores. (Supercenters are the equivalent of hypermarkets for example Cosco or Walmart (143,154). Less healthy food retailers category includes fast food restaurants and small convenience stores within census tracts. mRFEI reflects the percentage of the community food environment that is healthy, assuming that the rest of the exposure is less healthy. The mRFEI incorporates the concepts of the "food desert" and "food swamp" into a single indicator (154).

Food deserts were previously defined as areas with lack of access to affordable healthy foods that provide and facilitate a healthy diet (47). Food swamps were described as areas with a high exposure of energy-dense food options." (48). Thus, the index is able to express how the food environment might be both a "food dessert or food swamp". If the index scores zero, it represents a total food desert having no presence of healthy food at all. (154). A score of one hundred represents a healthy food environment, with only healthy food sources in the area. Lower scores represent few healthier food outlets and in addition, a food swamp or high exposure to obesogenic food pointing to areas where there are higher proportions of less healthy food sources compared to the number of healthy food retailers (154).

I adapted the index and included more food outlet classifications in both, healthy and less healthy categories. The study area used was the foodscape

instead of a census track. To calculate the healthy food sources category, I included all the outlets of the healthier food sources category previously calculated. In comparison with the classifications included originally, in addition to supermarkets, wholesalers, convenience traditional outlets and greengrocers, I also incorporated fishmongers, health food stores and traditional restaurants. Regarding the category of less healthy food retailers, in addition to fast food restaurants and small convenience stores, I incorporated another fifteen classifications from the previous studies These included:: candy (sweet) shops, restaurants, sit-in and takeaways greasy spoon type cafes, sandwich shops, clubs and associations, ten-pin bowling, sport-related pub/cafés, cinemas, amusements, vending machines, large and small discount stores, gift shops, butchers, bakers, pubs and mobile food vendors.

I calculated mRFEI using the following formula (154):

$$mRFE1 = 100 \times \frac{\#\text{healthy food retailers}}{\#\text{healthy food retailers} + \#\text{ less healthy food retailers}}$$

The calculation was $= 100 \times \frac{23}{23 + 172} = 11.8$

The score and its interpretation are described in the section 6.3 of the results chapter.

Appendix 12 Ethical approval

University of Edinburgh,
Centre for Population Health Sciences
RESEARCH ETHICS SUBGROUP

Self-Audit Checklist for Level 1 Ethical Review for PGR projects

See **Intra** website for further information:

NOTE to student: *Completion of this form should be under the oversight of your supervisor. A good strategy would be to complete a draft as best you can, then discuss with your supervisor before completing a final copy for your supervisor to sign.*

Proposed Project *(State research question and topic area, and briefly describe method/data. Specify also countries in which data will be collected):*

Main project: Exploring the community food environment and its obesogenicity in a deprived neighbourhood in Glasgow City

Aim, objectives and questions:
The study aims to explore the community food environment and its obesogenicity in a deprived neighbourhood in Glasgow City. To develop this aim, three objectives will guide this research:

a) Map the community foodscape
b) Describe the foodscape features
c) Assess the physical exposure of the population to healthy and less healthy food sources within the neighbourhood using geographic measures.

The following questions guide the project design:

a) What are the types of traditional and non-traditional food sources available to the residents?
b) Where are they located?
c) How many food sources are in the neighbourhood?
d) What type of food sources are closer to residential areas?
e) What type of food sources are more concentrated around residential areas?
f) Are there distribution patterns of these food sources?
g) Is there an obesogenic distribution and concentration of food sources in the area?

Methods:
Selection of the study site: the study will be conducted in Parkhead neighbourhood in Glasgow city. It represents the type of setting where a deprived food environment could be obesogenic. The neighbourhood has been classified in the first quintile of deprivation and among the 15% most deprived areas in Scotland. According to the Health Scottish Survey 2016, the highest prevalence of obesity was observed in the first and second quintile of deprivation. Additionally, previous studies have found that the densest retail outlet areas in Glasgow were Anniesland, Parkhead, Maryhill and Clydebank, making this a potentially suitable urban setting to research the community food environment.

Background: Obesity figures in the UK have trebled in the last 30 years, reaching the highest prevalence in Western Europe. According to the UN Food and Agriculture Organisation, the UK has become the "fat man of Europe." Scotland has one of the worst obesity records in the developed world and one of the highest rates of all OECD countries, where only the USA and Mexico have higher levels. Following the global pattern, Scottish men and women in the most deprived areas are more likely to be obese than men and women in the least deprived areas. This is evidence that the country is perhaps facing similar inequalities in health and life conditions as other regions of the world with high levels of obesity.

Beyond individual determinants, the complex social and physical contexts in which individual behavioural decisions are made strongly influence the outcome. Environmental factors may play a "crucial" role in determining eating and physical activity patterns at individual and community level. The international evidence has shown that specific urban settings such as deprived neighbourhoods encourage an "obesogenic" behaviour in the population living and/or working there. Studies from a residential perspective have described how these environments appear to encourage a higher energy intake and weight gain in a medium and long term, especially in those residents with less mobility such as the elderly and those on low incomes. According to McIntyre and Cummins, this may be explained due to a process of 'deprivation amplification,' whereby exposure to poor quality food environments amplifies individual risk factors for obesity such as low income, the absence of transport, and poor cooking skills or knowledge".

The relationship between the community food environments and obesity is less clear in Scotland due to the limited evidence generated in the last two decades. A few studies have assessed some variables of the food environment. The findings show that residents do have access to healthy food though these products frequently cost more than high caloric ones and, there is overexposure, regarding proximity and density, to less healthy or high energy-dense foods in the neighbourhoods, e.g. fast-food outlets. A foodscape is a snapshot of the food environment, and it is useful to visualize its components using a spatial neighbourhood analysis. This will be the first study in Scotland that seeks to map a complete community food environment and evaluate its obesogenic exposure in a deprived neighbourhood. It will constitute an updated line of research in Scotland, considering the evidence on this topic was produced mainly one decade ago.

Design: This will be a cross-sectional study design and it is composed of three consecutive phases summarized in the scheme below. In the first phase, it will establish a buffer area around Parkhead & Dalmarnock neighbourhood in Glasgow city, identify and categorize all the traditional and non-traditional food sources postcodes and map them into a foodscape through geocoding the postcodes within the established perimeter using the software QGIS. In the second phase, it will also calculate by category, the predominance of food sources within the foodscape and its proximity and concentration within the residential areas. Finally, in the third phase, it will classify the food sources as healthy and less healthy and compare the proximity, and concentration of both categories within the residential areas. This design will allow to take a "snapshot" of the community food environment, visualize the neighbourhood food sources exposure of the population that lives and/or works there and calculate the foodscape obesogenicity.

Data to be collected: all the traditional and non-traditional food sources postcodes in Parkhead and a buffer area will be identified and categorized. The collection of these data will imply the search of different printed and digital sources and a field validation. To identify and build a database with the food sources postcodes, different directories will be revised. The first two are the food and alcohol premises lists that will be obtained from Glasgow City Council, Environmental Health Department, Land and Environmental Services. These lists include the names, addresses, and postcodes of the premises they expend. To cross-check this data, the Yellow Pages and an Ordnance Survey product called AddressBase will be online-searched to examine the food retail outlets present in the neighbourhood. Food bank postcodes in the area will be revised in the Trussell Trust and the Independent Food Aid Network (IFAN) online websites. Finally, a field validation will be carried out to corroborate all the postcodes included in the database and to identify potential new food sources after mapping all of them. For mapping the foodscape, neighbourhood boundaries will be obtained from The UK Ordnance Survey (OS) Open Data™ products which are available through University of Edinburgh access. Data files are available in ESRI® shapefiles, provided as a ZIP file. To describe the population living there, I will use the dataset for 2014/15 provided by The Health and Wellbeing Survey (HWS) conducted by the NHS Greater Glasgow and Clyde (NHSGGC). These data will allow me to describe the health profile of the Parkhead population and neighbourhood characteristics. The measures that will be included are: health behaviours (smoking, drinking, physical activity, diet, BMI, and healthy and unhealthy behaviour indices), indicators of experience discrimination, crime, and feelings of safety) and perceptions of local places (public transport and food shops). The dataset is available through data linkage with the virtual platform Safe Heaven Data which stores all the survey data. No ethical approval from the NHS is needed to use the data, however, the Medical Research Council (MRC) course Information Governance is required. This course is freely available online

Data management and analysis: The names, addresses, and postcodes of the identified food sources will be included in a unique database in an Excel file. They will be categorized according to the 21-point classification tool developed by Lake et al. These criteria include the classifications used by the Food Standards Agency, Directory of the community food initiatives, Newcastle city council, and Glasgow city council. The postcodes will be geocoded within the neighbourhood map using the QGIS software. Every postcode will be introduced manually in the programme. It will differentiate the types of food sources on the map with different symbols and/or colours. It will also distinguish between the food sources within Parkhead and the buffer area. Three types of measures will be calculated to describe the foodscape: the predominance of the food sources by category, the proximity of the food sources to the centroids of the residential areas and concentration of them within residential areas. A comparison between the average distances of healthy and less healthy food sources within each residential area will be explored using a suitable proportion test depending on the number of final categories. Furthermore, a comparison of the densities of healthy and less healthy food sources within each residential area will be carried out using the ANOVA statistical test.

		Response	
		Yes	No
	y p f p p g ' g ersity into disrepute?		√

2.	**Data protection and consent** *Are there any issues of DATA PROTECTION or CONSENT which are NOT adequately dealt with via established procedures?* These include well-established sets of undertakings. For example, a 'No' answer is justified *only if*: (a) There is compliance with the University of Edinburgh's Data Protection procedures (see www.recordsmanagement.ed.ac.uk); (b) Respondents give consent regarding the collection, storage and, if appropriate, archiving and destruction of data; (c) Identifying information (eg consent forms) is held separately from data; (d) There is Caldicott Guardian approval for (or approval will be obtained prior to) obtaining/analysing NHS patient-data. (e) There are no other special issues arising about confidentiality/consent.		√
3.	**Study participants**		
a)	*Will a study researcher be in direct contact with participants to collect data, whether face-to-face, or by telephone, electronic means or post, or by observation? (e.g interviews, focus groups, questionnaires, assessments)*		√
b)	**Answer this only if question 3 above = 'YES':** *In ethical terms, could any participants in the research be considered to be 'vulnerable'? e.g. children & young people under age of 16, people who are in custody or care (incl. school), a marginalised/stigmatised group*		
4.	**Moral issues and Researcher/Institutional Conflicts of Interest** *Are there any SPECIAL MORAL ISSUES/CONFLICTS OF INTEREST?* (a) An example of conflict of interest for a researcher would be a financial or non-financial benefit for him/herself or for a relative of friend. (b) Particular moral issues or concerns could arise, for example where the purposes of research are concealed, where respondents are unable to provide informed consent, or where research findings could impinge negatively/differentially upon the interests of participants. (c) Where there is a dual relationship between researcher and participant (eg where research is undertaken by practitioners so that the participant might be unclear as to the distinction between 'care' and research)		√
5.	**Protection of research subject confidentiality** *Are there any issues of CONFIDENTIALITY which are NOT adequately handled by normal tenets of confidentiality for academic research?* These include well-established sets of undertakings that should be agreed with collaborating and participating individuals/organisations. For example, a 'No' answer is justified *only if*: (a) There will be no attribution of individual responses; (b) Individuals (and, where appropriate, organisations) are anonymised in stored data, publications and presentation; (c) There has been specific agreement with respondents regarding feedback to collaborators and publication.		√
6.	**Potential physical or psychological harm, discomfort or stress**		
(a)	Is there a FORSEEABLE POTENTIAL for PSYCHOLOGICAL HARM or STRESS for participants?		√
(b)	Is there a FORSEEABLE POTENTIAL for PHYSICAL HARM or DISCOMFORT for participants?		√
(c)	Is there a FORSEEABLE RISK to the researcher? *Examples of issues/ topics that have the potential to cause psychological harm, discomfort or distress and should lead you to answer 'yes' to this question include, but are not limited to: relationship breakdown: bullying; bereavement; mental health difficulties; trauma / PTSD; violence or sexual violence; physical, sexual or emotional abuse in either children or adults.*		√
7.	**Duty to disseminate research findings** *Are there issues which will prevent all relevant stakeholders* having access to a clear, understandable and accurate summary of the research findings if they wish?* **If, and only if, you answered 'yes' to 3 above, 'stakeholders' includes the participants in the research*		√

Overall assessment

➢ If every answer above is a definite NO, the self-audit has been conducted and confirms the *ABSENCE OF REASONABLY FORESEEABLE ETHICAL RISKS – please tick box* √

*This means that regarding this study, as currently self-audited, no further ethical review actions are required within CPHS. However, if in the coming weeks/months there is any change to the research plan envisaged now (and outlined above), the study should be **re-audited** against a Level 1 form because it may be that the change made negates the absence of ethical risks signed off here.*

- If one or more answers are YES, then risks have been identified and prior to commencing any data collection **formal ethical review** is required - either:
  - By NHS REC (NB copy of ethics application and decision letter to be sent to CPHS Ethics); or
  - If not to be formally reviewed by NHS REC, then CPHS level 2/3 ethical review required.
    [If either 4 is 'yes' or 3b is 'vulnerable' then it is possible level 3 review is required.]

Two copies of this form should be taken for inclusion in the final dissertation/thesis and the original should be returned to the CPHS Ethics administrator.

Andrea Fuentes Pacheco	Liz Grant (PhD)
Student Name	Supervisor Name
Student Signature	Supervisor Signature*

*** NOTE to supervisor:** *The CPHS Ethics Subgroup will not check this form (the light touch Level 1 form means we have insufficient detail to do so). By counter-signing this check-list as truly warranting all 'No' answers, **you** are taking responsibility, on behalf of CPHS and UoE, that the research proposed truly poses no potential ethical risks. Therefore, if there is any doubt on any issue, it would be a wise precaution to mark it as 'uncertain' and contact the Ethics Subgroup as to whether a level 2 form might be required as well. (See Intra Ethics website – URL at top of form)*

Appendix 13 The base map. Whitewood Neighbourhood and the buffer area